GREENING THE TEA INDUSTRY IN EAST AFRICA

SMALL HYDRO POWER SCOPING STUDY

MOZAMBIQUE

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Final Report

EATTA

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GEF

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ACRONYMS

GoM	**Government of Mozambique**
WB/IDA	**World Bank / International Development Association**
UNEP	**United Nations Environment Programme**
GEF	**Global Energy Fund**
EATTA	**East African Tea Trade Association**
SHP – SHPP	**Small Hydro Power Plants**
IPP	**Independent Power Producers**
PPA	**power purchase agreement**
PWA	**power wheeling agreement**
SADC	**Southern African Development Community**
ME	**Ministry of Energy**
UTIP	**Technical Unit for Implementation of Hydroelectric Projects**
DNEE	**National Directorates of Electrical Energy**
DNENR	**National Directorates of New and Renewable Energies**
MICOA	**Ministry for Coordination of Environmental Affairs**
FUNAE	**National Energy Fund**
CNELEC	**National Electricity Council**
EDM	**Electricidade de Moçambique**
HCB	**Hidroelectrica de Cahora Bassa**
CDM Lda	**Chazeiras de Mozambique Limitada**
SDZ Lda	**Sociedade de Desenvolvimento de Zambezia Limitada**
CTC	**Cut – Tear – Curl (tea process)**
TS	**Thé Sec = made tea**
GDP	**Gross Domestic Product**
MZM	**Mozambique Metical**

PHYSICAL UNITS

ha	**hectare**
LV – MV – HV	**low – medium – high voltage**
kV	**kilo Volts**
kW – MW or MWe – GW	**electrical power in kilo – mega – giga Watt**
kWh – MWh – GWh	**electrical energy in kilo – mega – giga Watt hour**
kVA – MVA	**active power in Volt Ampere**
kVAR	**reactive power in Volt Ampere Reactive**

Exchange rate in Mozambique : 1 USD = 28,000 and 1 EUR = 31,000 in Feb. 2006

1. BACKGROUND

1.1 PROJECT OBJECTIVES

The goal of the proposed Small Hydro Program for "Greening the Tea Industry in East Africa" is to reduce the electrical energy in the tea processing industries in countries covered by the East African Tea Trade Association (EATTA, 150 tea factories), while increasing supply of clean power, enhancing its reliability and reducing Greenhouse Gas emissions through the removal of barriers.

More specifically the project aims to reduce barriers related to financial weakness, lack of technical awareness and capacity as well as all obstacles related to power sector policy frameworks.

In particular the project aims to establish 6 mini hydro demonstration projects in at least 3 of the EATTA member countries, preferably with an attached rural electrification component, and prepare in addition a total of 17 pre-feasibility studies. Both studies and actual installations shall serve as training grounds for the entire tea sector in the region. In addition a special financing window shall be designed that will provide incentives for individual tea processing plants to move into "green power generation". The near-term objective of this project is the preparation of a Full Size Project (FSP) Brief presenting in detail how the above goal will be released and compiled in line with UNEP/GEF and GEF Secretariat requirements for submission to the GEF Council.

For Mozambique, which has enormous small- and micro-hydro potential and long history in the tea sector (currently 5 tea factories in operation with 3 from EATTA members), the specific objectives are :

- if possible to get some pre-feasibility studies for sites selected among a list given in this scoping study (see § 3.7),
- if possible to get one demonstration project,
- to catch the opportunities offered by the financing window and by the Full Size Project, being prepared.

1.2 TEA PRODUCTION IN MOZAMBIQUE

1.2.1 Historical context

Until the early 1980s, Mozambique was Africa's third largest tea producer, after Kenya and Malawi. This position resulted from almost ideal agro-ecological conditions for tea cultivation, a strong degree of government support, and access to a pool of cheap labour.

Black tea production, confined to a few districts in upper Zambezia, was once a strategic sector not only for the economy of that region, but also for the country as a whole. Locally, tea growing employed a large number of workers while the demand and savings accruing from salary income supported a whole range of local economic activities, from agriculture to trade, services, and small-scale rural industries. Nationally, tea contributed significantly to exports and – to a lesser degree – to the state budget.

Tea growing was introduced into the Milange highlands of upper Zambezia in the early 1920s. However, it was after World War II that this activity developed in a significant manner, assisted by a state that not only provided easy access to land and credit, but which also guaranteed a steady supply of cheap labour to the tea estates1. The physical proximity to Malawi's tea industry was another determining factor in the initial establishment and subsequent development of tea production.

Encouraged by favourable natural conditions, generous state incentives and Malawi's successful experience in tea making, several small entrepreneurs as well as some large agricultural companies decided to venture into tea production. Hence, at one extreme, there were a number of small family-based estates with less than 100 hectares and no in-house processing capacity. At the other extreme, there were a few larger estates with more than 500 hectares and some processing facilities where small producers used to come with the green leaf production.

In 1960, there were a total of 18 factories processing the production from about 14,000 hectares. Most of the total production (10,000 tons) was coming from Gurué district. Made tea production has continued to rise up to 19,000 tons until independence in 1973. In Gurué only, almost 20,000 workers were employed on seasonal basis. Despite those progress, the Mozambican tea sector was still characterised by structural weaknesses as a serious deficit in processing capacity and weakly managed firms.

After independence, the tea estates and factories were gradually brought under state control that reflected the country's shift towards centralised economic planning. The nationalisation of the tea sector culminated in 1978 with the constitution of the state-owned company EMOCHA, which took over the management of about 14,000 hectares of tea plantations and 19 of the 21 processing units. Only Madal and Companhia da Zambézia retained ownership and management over their tea estates and factories. Thanks to investment in 3 new state-owned factories and upgrading of existing ones, the made tea production has reached record level of 22,194 tons in 1981 with a yield higher than 1,2 tons per hectares.

Unfortunately, the production collapsed during the 1980s and early 1990s with the intensification of the internal conflict and the progressive damage to equipment, infrastructure, transportation, energy network, etc. By the late 1980s only six factories were still operational, while made tea production had fallen to less than 2,000 tonnes per year. By 1993 EMOCHÁ had stopped processing green leaf.

Since 1995, the new economic policy of the Government lead to the privatisation of EMOCHA and the sale of tea companies to local or international investors. Most of the government-owned plantations and factories have been purchased by privates but till now few have actually current tea production because of the considerable investments and working capital requirements needed to re-launch tea activities on a sustainable basis, i.e. under a much less favourable policy and market environment than in the past.

While the sector has been recently privatised, no major recovery has taken place yet to revive Mozambique's tradition and potential as a major tea producer. Production yield - that reached 1.5 tons/hectare in 1981 - remains too low (< 1 ton/he) compared to neighbour competitors (> 2 tons/he in Kenya). And quality remains probably doubtful for foreign buyers

Today only 5 factories are producing tea (or re-launching the production) over the 21 factories that were existing before in Mozambique before the civil war period (see further map). They are putting efforts to support local development of rural economic activities.

There is no national source of information giving an overview of the whole tea production in Mozambique and data as total tea catchment area, green leave production, made tea production and export values over the years.

1.2.2 Companies and factories

The present world tea market conditions and the advanced state of destruction of tea plantation and processing facilities are severely constraining the investments in the tea sector in Mozambique. Today, there is no state institution specifically responsible for promoting the development of tea production, unlike other countries[1].

Despite the lack of support from government and the reluctance of banks for loans, 5 private companies, usually supported by large multi-disciplinary groups, have taken up the challenge and have invested in factory and old field rehabilitation over the last decade. All those tea producers are located in the Zambesia province and in particular in mountainous region of Gurué and Socone districts.

Today only 3 of them are EATTA members.

- **Chazeiras de Mozambique** Limitada (CDM Lda) is part of the Gulamo group, with 2 tea estates and two factories (called UP4 and UP6 before the privatisation) in Gurué since 1998.
    - Concerned by local rural development and try to make use of the 2,340 hectares of land for various agriculture and livestock development (tea and other).
    - The company owns 2 tea plantations and 2 factories separated by less than 5 km. Only one factory has been rehabilitated (520m) and is partly supplied by the national grid and by the small hydropower supply located at about 2 km.
    - SHP experience with a 400 kVA on the Licungo river since 1960's. A larger turbine unit was delivered in the 70's but never installed. The company has locally very good technical skill in O&M but also in reconditioning hydro turbines. Equipment are in a very good shape although dating from 1960s!
    - Annual capacity is estimated at 1500 tons for 1,400 hectares in 2005 (1,200 tons for 2000/2001, with 0.82 tons/hectare).
    - With the total usage of the 2,340 hectares and a yield of 2.7 tons/he, the production could reach the maximal capacity of 6600 tons/year.
    - Production in 2005 has been reduced to 862 tons partly due to rainfall shortage but also due to effort to improve tea quality.
    - Exporting to Mombassa, Pakistan and Yemen.
    - Local employment of about 2,600 workers in the peak season, with about 200 worker houses and 35 staff houses. There are no independent growers selling tea leaves. The factory is run by 4 executives only.
    - Investment for rehabilitation, new production and social infrastructures has reached 7.65 million USD between 1998 and 2003 (50% for equipment and infrastructures).

[1] This explain also why very little information is available on national tea sector.

- In addition, 1.1 million USD have been invested in 2 tea bagging and packaging facilities (first one in Gurué and a new one in Maputo). The new facility will employ 60 workers and will produce about 3.6 tons per shift (8h).

- **Sociedade de Desenvolvimento de Zambezia Limitada** (SDZ Lda) is owned by two private shareholders, SCI holding (82.83%) and Emochá (17.17%), and is active in the tea sector since 1999 in the Gurué district. They have special concern to promote rural development in Northern areas.
  - SDZ has a total of 7,385 ha of land in the vicinity of Gurué City. 1,655 ha of the land are tea plantations of seedling tea, of which 1,155 ha are in production and 500 ha need to be rehabilitated. There are also 135 ha of eucalyptus and 25 ha of rubber;
  - SDZ has two tea factories with a production capacity of 5 tons of made tea per day and 2 tea estates (1,150 ha). One, called UP5, has a new production line for CTC tea commissioned in October 2004. The other, called UP3 has a production line for Orthodox tea where several parts of the production line are new.
  - Tea production has been increasing year after year and last season (July 2004-June 2005) reached about 1,400 tons of made tea, compared to 600 tons in 2000. Almost all the production is exported and about 90 % is sold in Mombassa Auction.
  - An independent evaluation made in October 2003 at the request of NORSAD valuated the assets of SDZ has follows: Buildings USD 3,490,500, Equipment USD 975,000; tea and other plantations USD 2,991,200. Since that evaluation SDZ both a tea plantation with 354.5 ha of which 280 ha are of tea plantations. Additionally invested USD 350,000 in the new production line for UP5 and transport equipment.
  - SDZ has no experience in hydropower yet but is seriously interested by this alternative.
- **Sonil** Lda is a fully private company involved in different activities as tea, tobacco and trading has with one factory in Socone (Ile)
  - Cha' Socone factory is now connected to the grid after having rely only on micro-hydropower for many years..

- Production : no information have been obtained on the company profile and their production.
- Recently member of EATTA

The non-EATTA member tea companies are :

- **Companhia Agrícola João Ferreira dos Santos**, JFS SARL, has bought 2,600 hectares of plantations from government including 2 tea factories and one hydropower station (UP 8, 9, 10) but only part of it has been rehabilitated for tea production. JFS company was member of EATTA until recently but has now been sold to a Indian company that has started already tea production.
- **Companhia da Zambézia**, CDZ, in Gurué has maintained the control over their tea estates after independence. The factory has been recently sold to an Indian company that plan to start production next year. In the mean time the green leaf production is sold to and processed at SDZ Lda.
- Another company **Organizacões Namarroi** had purchased one old factory and 2 tea plantations (UP1 and UP2) from the government but the production has stopped after the civil war. The factory was supplied by a micro-hydro power plant of 400 kVA on the Luça river.
- A last company **Carlos Alberto Venichand** purchased one plantation (UP12), including tea factory and hydropower plant (500 kVA) but the production has also stopped, a short time after starting.

The Mozambican tea sector has been out of production for a long period due to the civil war. To become competitive in the International Market, further investments are needed to bring the quality of the tea and the yield per ha to the standards achieved by the other seedling tea estates of the neighbour countries.

All companies recognise the difficulties of the tea business and that further efforts and investments are needed to reach profitable level, in particular through improvement of the agricultural practices (introduction of new high-yielding varieties, adequate utilisation of available land, introduction of irrigation and of mechanical plucking as well as of an out growers scheme) and improvement of the technical management of tea factories.

With adequate investment, considerable cost reduction are expected by lowering labour, transportation and energy costs per ton of made tea. A serious threat remains; severe droughts have not facilitated the production over the 2 last years.

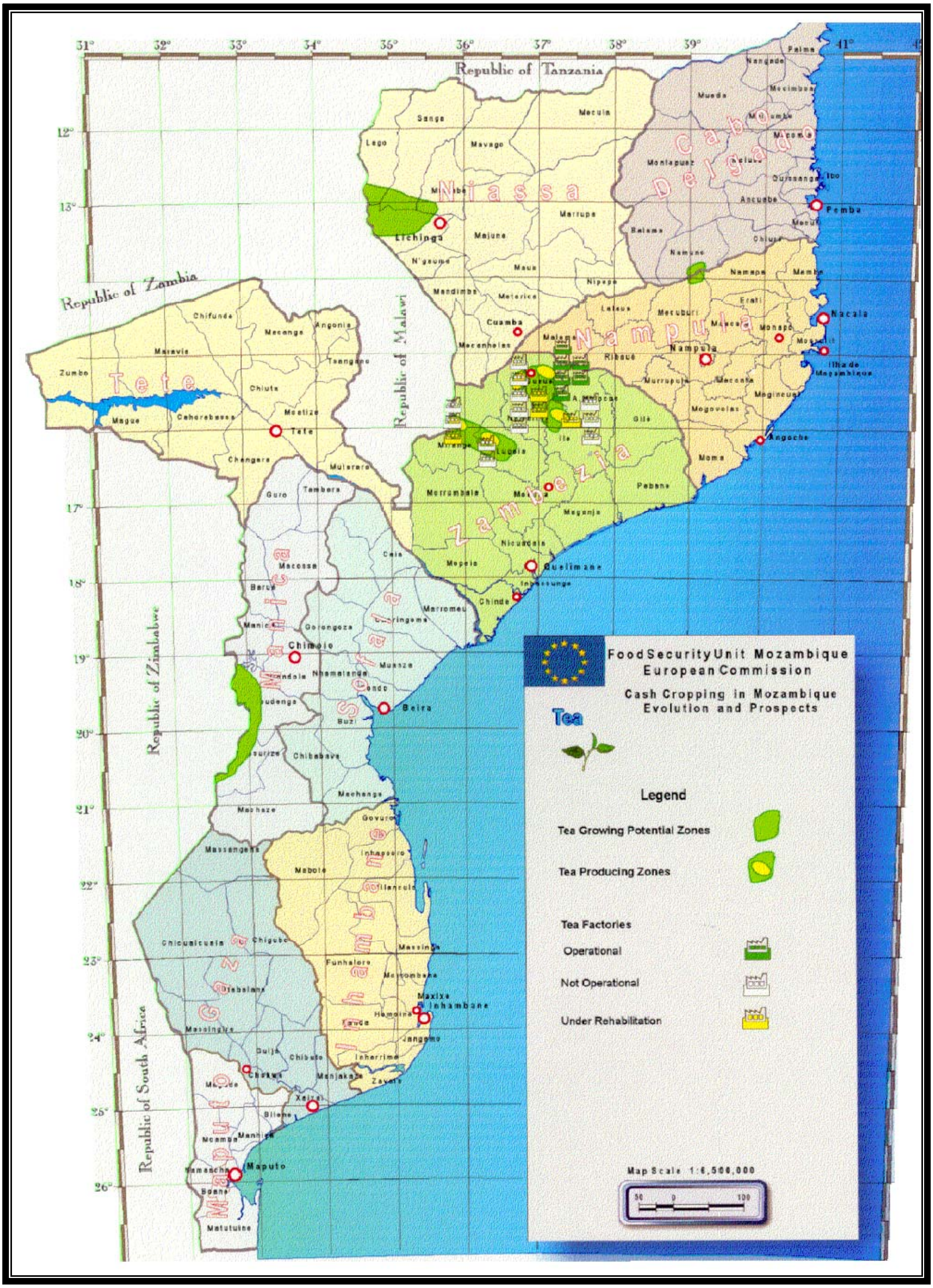
Although the estimated annual per capita consumption of made tea in Mozambique is rather low, the local tea market is believed to be a cost-effective alternative to the traditional Mombassa auction market, where prices are rather low and recent restrictive quality certification have been laid down.

1.2.3 Factory & plantation location

All companies have invested in some new process equipment including boilers or furnaces in their factories. Nevertheless, many other equipment are outdated and lack of maintenance. Electrical installation have never been reconditioned and are in poor shape.

All the factories are located on the south side of the Namuli mountain range, between 600m and 1200m. The map below shows Mozambique's tea areas and provides an indication of the location and status of tea factories (not updated). In addition, it shows other regions of the country with suitable agro-climatic conditions for tea cultivation.

Figure 1 : Country map



1.3 INTRODUCTION TO THE POWER SECTOR IN MOZAMBIQUE

Resources

Mozambique is one of the largest power producers in the SADC region. Hydropower is Mozambique's most important commercial energy resource, with the potential estimated at about 14,000 MW, of which about 2,300 MW has so far been developed, 2,075 MW at Cahora Bassa Dam over the Zambezi River and the remaining is distributed among a number of sites throughout the country. All of the capacity at Cahora Bassa, except for Mozambique's entitlement of around 300 MW, is committed to the supply of electricity to South Africa, Zimbabwe, and Malawi.

Apart from hydro resources, Mozambique has not much economically exploitable oil reserves but it has large sedimentary basins of gas. Presently three accumulations of gas have been discovered on-shore in 2 provinces (Inhambane and Sofala). Total natural gas reserves might be as high as 100 milliard of m^3. The production of gas is now being exported to South Africa through a pipeline and not yet used for power generation.

Concerning coal resources, Mozambique has three relatively large known deposits in the Province of Tete. Total coal reserves are estimated at about three billion tonnes. Coal has been produced since 1940, from Moatize underground mines, both for in country use and export. The operations had to be suspended in 1981 due to civil war but it is planned to restart the activities.

Power sector

The national energy supply falls into three distinct categories, namely, National Grid, Mini-Grids and Independent Systems.

The responsibility of the national grid network falls to the power utility Electricidade de Moçambique (EDM), under supervision of the Ministry of Energy (ME). EDM, established by the state in 1977 two years after independence, is responsible for generation, transmission and distribution, but there are other independent power companies (IPPs) that produce and distribute electricity. The main one is Hidroelectrica de Cahora Bassa (HCB), a company jointly owned by Portugal (82%) and Mozambique (18%) running the biggest hydroelectric scheme in Southern Africa.

Mini grids are under the responsibility of the Ministry of Energy through the provincial directorates and/or donor specific initiatives. The management is undertaken privately, typically led by the District Administrations. The Provincial Directorates of Energy at provincial level are responsible for the design, installation and quality management of the mini grid systems. These systems are typically found at District Headquarters level and feed the commercial centres and local services. Households are eligible to sign up but few do so in most cases, due to payment constraints.

Below the mini-grid level, responsibility for electricity access or energy services to institutional facilities through independent systems falls to individual Ministries (e.g. Health, Education) for providing essential services.

Production

Beside the large Cahora Bassa hydro scheme operating at full capacity, other large hydro plants in Mozambique have continued to operate at less than full capacity, including Mavuzi (44.5 MW effective capacity out of 52 MW nominal capacity); Chicamba (34 MW of 38.4 MW); and Corumana (14 of 16.6 MW).

Hydroelectric power continues to be the main source of electrical power in Mozambique. Still in the Zambezi River there are plans to construct other hydropower units : in the northern side of Cahora Bassa, with a capacity of 850 MW; in the south, the Mpandha Nkuwa Hydro Scheme, with a capacity of 1,300 MW in the first phase and 2,400 or 2,600 MW in the second phase (studied by EdM and Eskom); the Baroma scheme (444 MW) and Lupata scheme (654 MW). Development of these projects may be carried out following power purchase agreements with neighboring countries. Other hydro projects include the construction of a dam on the Incomati River in Maputo Province.

The next table gives the installed generating capacity and production of EDM by fuel.

Fuel/Source	Capacity (MWe)					Power generated (GWh)				
	2000	2001	2002	2003	2004	2000	2001	2002	2003	2004
Hydropower	108.85	108.85	108.85	108.85	108.85	254.6	257.8	262.6	243.1	108.8
Diesel	198.8	198.8	127.33	127.33	127.33	41.6	42.6	33.8	33.5	38.6
Gas and Coal										
TOTAL	307.65	307.65	233.17	233.17	233.17	296.2	300.4	296.4	276.6	147.4

Source: EDM Annual Statistical Reports 2000-2004

There is great potential for cheap electricity through the exploitation of hydropower and the country's vast natural gas deposits are another important source of energy. Inefficient use of already established utilities contributes to the fact that in 1999 only 5% of households in Mozambique had access to electricity.

Mozambique’s generating capacity totals some 2,468 MW. The majority of capacity is provided by the 2,075 MW Cahora Bassa hydroelectric project operated by HCB. The national utility EDM has an installed capacity of about 393 MW. 85% of the electricity generated by EDM in 2002 was from hydroelectric sources, with the remaining 15% coming from thermal sources. Installed nominal capacity and available capacity in 2003 (some turbines or generators are out of work) are presented in the table below for EDM power stations. The peak demand is expected to increase by 40% in 5 years, in the medium growth rate scenario (557 MWe in 2006). About 120 MWe are planned to be supplied by natural gas-based power stations before 2006.

Name of power plant	Type of power plant	Fuel	Nominal Capacity (MWe)	Avail Capacity (MWe)
Mavuzi	Hydro	Hydro	52.00	28.50
Chicamba	Hydro	Hydro	38.40	17.00
Corumana	Hydro	Hydro	16.60	14.00
Cuamba	Hydro	Hydro	1.10	1.00
Lichinga	Hydro	Hydro	0.75	0.60
Angoche	Thermal	Diesel	0.91	0.39
Beira	Thermal	Gas	12.00	12.00
Inhambane	Thermal	Diesel	6.12	2.20
Lichinga	Thermal	Diesel	1.84	0.97
Lionde	Thermal	Diesel	3.43	1.00
Maputo	Thermal	Gas	78.50	52.00
Tete	Thermal	Diesel	0.82	0.60

Mocuba	Thermal	Diesel	0.84	0.35
Cuamba	Thermal	Diesel	0.42	0.35
Nacala	Thermal	Diesel	9.90	1.20
Nampula	Thermal	Diesel	6.40	5.20
Pemba	Thermal	Diesel	8.50	7.10
Quelimane	Thermal	Fuel oil	6.88	3.20
Xai-Xai	Thermal	Diesel	2.49	0.00
Total	**Hydro**		**108.85**	**61.10**
Total	**Thermal**		**139.05**	**86.56**
Total	**All**		**247.90**	**147.66**

It should be noted that EDM is gradually reducing its generating capacity from thermal sources by purchasing more power from the independent power producer (IPP), as HCB, for its network. In 2003, EDM bought from HCB 1,543 GWh compared to 834 GWh in 2000.

EDM, although supporting medium and large hydro power plants, is also interested by small & micro-hydro scheme as a appropriate option for rural electrification and government target. EDM is already operating 2 micro hydro stations grid-connected. More recently an IPP is implementing a new one of 1.7 MW on the Limpopo river and a PPA is under discussion with EDM.

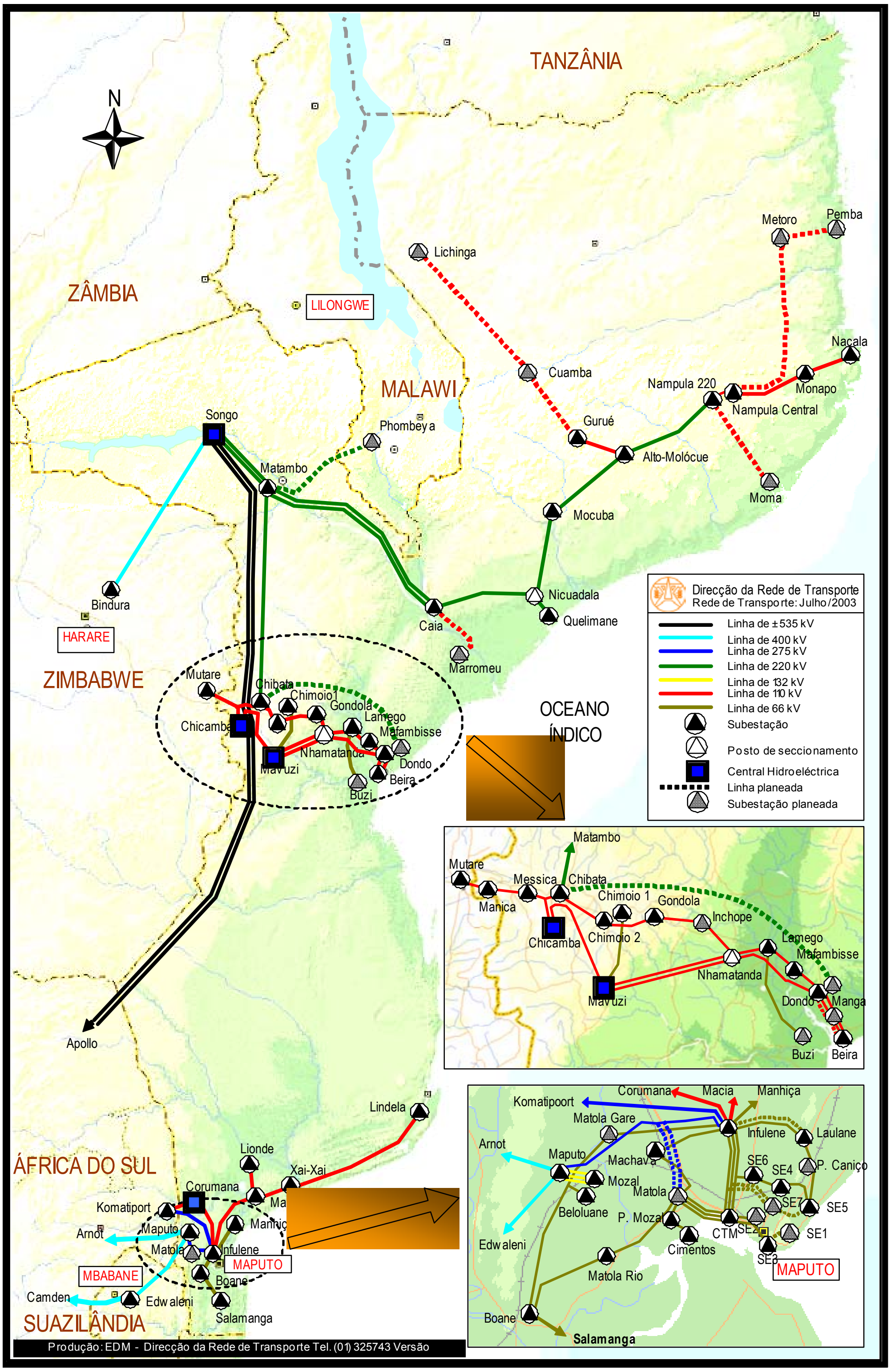
Transmission & Distribution

EDM is a member of the Southern African Power Pool (SAPP[2]) regulating all imports and exports of power in the region. EdM has agreements with neighbour countries (South Africa, Zimbabwe, Malawi) to rehabilitate or extend transmission lines.

The following map illustrate the transmission and distribution network of power managed by EDM in Mozambique. The EDM transmission system includes more than 3,500 km of HV overhead lines ranging from 66kV to 535 kV and covering mainly three regions of the country, North, Centre and South. The distribution network (BT and MV lines) equal to 6,500 km.

[2] Inter-Utility Memorandum of Understanding between power utilities from Botswana, Mozambique, Angola, Malawi, South Africa, Swaziland, Democratic Republic of Congo, Namibia, Tanzania and Zimbabwe

Figure 2 : Power network map



Consumption

Average energy consumption in the country is 40 kg oil equivalent per capita. The energy from the main grid covers only about 6% of the about 18 million inhabitants of the country. People outside the grid are mainly those living in rural and in peri-urban areas.

Power demand and supply is strongest in the South and is expected to grow with the development of interconnections with other power systems in the country. Key industrial projects are to be developed in conjunction with energy and power projects (in particular aluminium and steel industries).

EDM customers are classified into 4 categories : Residential, Commercial, Industrial and Agricultural. In 2004, the residential consumers (LV domestic) and industrial (MV or HV) consume respectively 447.4 and 496.4 GWh from the total 1187.4 GWh.

The Master Plan of EDM, from 2004, discusses deeply the developments of the electricity sector in the country, giving also a demand/supply forecast for the next years until the year 2010. EDM is publishing a detailed annual statistical report.

Rural electrification

Electricity coverage in the country is still very low in all categories. For instance, the average level of access of domestic energy is of only about 6%, one of the lowest in Africa, and varies from province to province. The northern provinces, including Zambézia where tea is produced, have levels of access of less than 2%, mainly in the rural towns (2004). To compare, the province of Maputo has a level of access of 24.5%.

One of the main problems of energy and electricity access in Mozambique is its high cost relative to local incomes and the need to balance these with other expenditures. The low rate of national and mini-grid subscribers is due in large part to the inability of users to pay for these services. In genset served centres it is mainly commercial institutions and the Administration buildings along with the local health and education facilities that are connected. The electricity tariffs will be presented in the section § 2.1.

Nevertheless, several rural electrification projects are planned or ongoing, as a US$ 24.33 million project, funded by the OPEC Fund and EDM with a secured loan from the African Development Fund (ADF). These project aims to enable rural communities from 19 towns in Gaza, Inhambane, Tete and Nampula provinces to increase their economic activity and improve their standard of living through the provision of electrical power. The bulk of the money for the project will be spent on the construction of 895.5 km of MV overhead line (33 kV), 72 km of BT lines and the erection of 76 pole-mounted transformer stations (33/0.4 kV).[3]

Beside this EDM is investing between 40 and 50 millions of USD for grid extension in rural areas every years. The target is to reach 15% of penetration by year 2020.

A Strategy for Rural Electrification in Mozambique has been prepared by Norplan in 2000 and is available at Ministry of Energy. Bidding process for a new Rural Electrification Master Plan has been launched recently by the government.

1.4 DEMOGRAPHY – COUNTRY FACTS

Mozambique had an estimated population of 19 millions of inhabitants in 2004 (24 inhab./km²). More than 80% of the population live in rural areas concentrating along the coast (more than 50%). This population is mostly young (45.9% is less than 15 years old).

[3] **http://www.mbendi.co.za/indy/powr/af/mz/p0005.htm**

http://www.small-hydro.com/

In 1994, Mozambique ranked as one of the poorest countries in the world. Since that time, the country has undertaken a series of economic reforms. Almost all aspects of the economy have been liberalized to some extent. More than 900 state enterprises have been privatized. Mozambique has considerable mineral resources although exploitation has been limited by its recently ended civil war. Discussions are underway to exploit the large reserves of natural gas in the Pande region which is set to become a major source of foreign exchange.

Mozambique ended a 16-year civil war in 1992. The country has remained stable following Mozambique's first multi-party election in October 1994 and subsequent elections in December 1999. Since 1996, inflation has been low and foreign exchanges rate stable. Albeit from a small base, Mozambique's economy grew at an annual 10% rate in 1997-99. However, this tendency was broken down in 2000 and 2001 years due to the worst floods that country experienced.

Agriculture is the most important sector and is mostly carried out by peasant farmers who cultivate 92% of the total cropland. Commercial farming occupies only 250,000 hectares, or 8% of the total land cultivated. Though the contribution of agriculture to the Gross Domestic Product (GDP) is about 30%, an estimated 80% of the country's population gains its livelihood from this sector emphasising the importance of agriculture to the nation. Most of the agricultural activities rely on rain that falls from November to December and are limited to one season. In few cases, irrigation has enabled the farmers to grow an additional crop during the dry season. The forests and other native species are distributed over an area of about 80 million ha, that corresponds to 78% of the total surface of the Mozambican territory. 8.7% of 80 million ha, correspond to high productivity forests, 26% to low and medium productivity and the remaining 65.3% to dense savannah, with low economic value. However, this has high social value, as it is the basis for the source of wood fuel, building material, pasture, food and medicinal plants. Tea counts among the main exports of the country, along with prawns, cotton, cashew, sugar, and copra.

2. EXISTING ENERGY RESOURCES FOR TEA FACTORIES

2.1 ELECTRIC POWER (INCLUDE THERMAL PRODUCTION)

2.1.1 Grid

Gurué and Ile districts have been connected to the national grid only in the year 2004. Before that, the town was supplied by an isolated thermal power plant and the surrounding tea factories were relying on small hydro- or on diesel-based generators. Gurué town has a 110 kV substation and most of the factories are now connected through 33 kV lines and 33/0.4 step-down transformers.

2.1.1.1 Tariffs

The national tariff scale (see next table for 2005) is established to encourage the connection of domestic households and the low voltage consumers with a special attractive social tariff without fixed subscription or monthly fees. The higher tariffs for commercial and industrial operators with penalties for excessive consumption is supposed to compensate the low domestic tariffs. A new tariff for 2006 is actually in force with the same structure as before but all prices have to be increased by 10,9%.

Tea factories are typically paying more than 2,100 MZM per kWh (10 US cents/kWh), including all taxes (17% of VAT) and penalties for overrunning of the subscribed capacity.

The penalties for reactive power starts only when the reactive power is higher than 75% of the active power, and is about one third of the tariff for the active power.

Tariff in USD (2005) *1 USD = 25,000 MZM*

Small LV Consumers		(USD/kWh)			
kWh/month	**Monthly fee**	**social**	**domestic**	**agricol**	**comm.**
0 - 100	-	0.03	-	-	-
0 - 200	2.31	-	0.07	0.07	0.08
201 - 500	2.31	-	0.10	0.10	0.11
> 500	2.31	-	0.10	0.11	0.13
Prepayment	-	0.03	0.09	0.10	0.12

Large MV/HV Consumers			
Category	**Monthly fee**	**Extra kW**	**Extra kWh**
Large LV	6.76	3.46	0.04
MV	31.75	3.87	0.04
HV	31.75	4.26	0.03

2.1.1.2 Power outages and other grid related problems

Since Gurué is on the 110 kV line, the area doesn't suffer so much from power outages or voltage drops. Only when the country faces serious water shortage as in 2005, frequent power shortage and load shedding occur in rural areas. Any shortage of power weighs heavily on local industries, in particular on the rural tea factories.

During worst period, tea factories are suffering from random shedding that stops all the tea processing (each stage is using motors or fans) and that may occur several times a day or even a complete day. Manual switching from grid to stand-alone generator takes usually 10 to 20 minutes. And when the power grid is back, the re-connection of the whole factory to the grid generates high reactive power and penalties that are kindly demanded in the electricity bill.

Grid voltage and frequency fluctuations are occasionally observed by tea factories (no logbooks) but none complains really on any electrical equipment damage. On the contrary, the grid is often preferred compared to the poor quality of their hydropower station. The EDM office in Gurué announces 97% of power availability at the transmission level.

2.1.2 Diesel isolated generation

Backup systems with thermal diesel generators (usually between 200 and 400 kW) is essential for all factories. Unfortunately, power outages are neither planned nor announced in advance resulting in random process interruptions and losses in quantity and quality of tea production.

Despite the very good maintenance skills noticed in one of the tea factory, the diesel gensets are pretty old and worn, leading to high fuel & oil consumption.

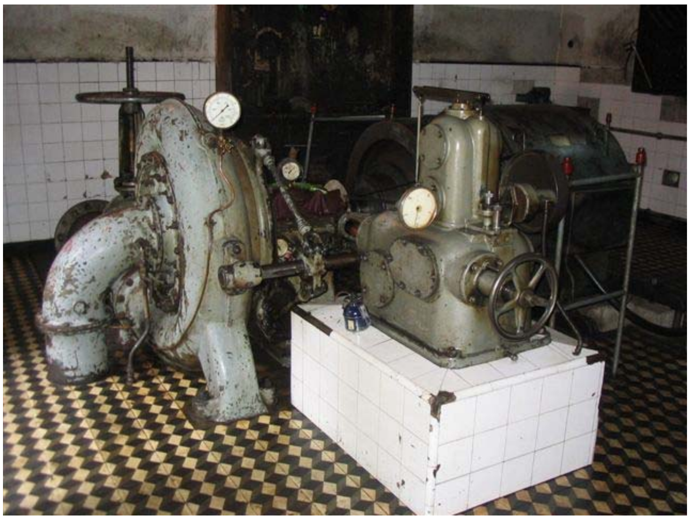
It seems that main power shortage have not been serious enough to justify the procurement of a second diesel generator. But unexpected genset breakdown or maintenance when grid is off will result in production interruption and the need to transport local green leaves production to other neighbour factories.

If the trend of rainfall shortage is confirmed in the region, the tea factories might shortly decide to increase their diesel generation capacity. This will strongly affect the production cost as the fuel cost is related to transportation, heavy government taxes and worldwide economical situation.

For comparison, EDM is estimating the operating cost of their back-up diesel-based generator at about 20 US cents/kWh, with a high value of 35 cents for poor efficiency generators.

2.1.3 Small hydro power plants

Mapping of hydro resources for medium and high size hydro plants has been made in around 60 rivers throughout the country, during the seventies (see Appendix C : list of potential hydro sites). No specific study has been undertaken for small hydro power plants, but the Ministry of Energy has plans to start such a study in 2005-6. The previous study on medium and high size plants reveals that the potential is very high in the central (provinces of Sofala, Manica and Zambézia) and northern (provinces of Nampula, Cabo Delgado and Niassa) parts of the country. The South (provinces of Maputo, Gaza and Inhambane) is relatively poor in hydro resources for energy generation.



The tea producing areas, which are concentrated in the province of Zambézia, districts of Gurue, Ile, Milange and Lugela, have very good hydro energy resources, according to an energy survey undertaken by the National Energy Fund (FUNAE) in the year 2004. All four districts were producing tea until the seventies and production was interrupted due to civil war. In fact the survey identified the use of micro hydro plants in the tea industries, most of them not yet rehabilitated after the war ended. Hydro schemes in tea plantation areas are attractive not only where there is no electricity from the grid but also where the electricity from the local hydro schemes can be cheaper than that provided by the utility.

The Gurué and Socone areas are considerably appropriate for small size hydropower generation. Many rivers are flowing down from the flanks were tea is grown. At the time of the first tea plantations (1960s), the national grid was far to reach the factories. Hydropower stations were implemented in at least 5 factories, ranging from 400 to 1,000 kVA.

Today, despite the long civil war, 3 turbines are still used to produce part or totality of the power requirement of the operating tea factories (UP-4, UP-8-9-10, Cha Socone). The factory of Socone is still not connected to the grid and fully rely on hydro- and diesel-based generation. The next table summaries major information from the tea factories in the area.

Company		Tea Estate Location				Hydro Power – Old Data		
Owner	EATTA	UP	Old name	District	Map	SHP		River
					n°	kVA	Status	
CDM	**yes**	4	Moçambique	Gurué	471	500	OK	Licungo
		6	Gurué	Gurué	509/508	-	-	-
SDZ	**yes**	3	Coopag	Gurué	471	-	-	-
		5	Junqueiro	Gurué	472	-	-	-
		7	Narre	Gurué	509	-	-	-

Sonil	**yes**	Socone	Napela, Montemuli, …	Socone	509/546	?	OK	Loci?
JFS (> indian)	before	8,9,10	Monte Bravo, Luso, Mualaca	Gurué	472/509	?	OK	Duduce?
		11	Muchocha	Gurué	472	-	-	-
CAV – Venich.	no	12	Metilile	Gurué	472	500	?	Malema?
CDZ (> indian)	no	CdZ	-	Gurué	471	-	-	-
		CdZ	-	Gurué	471	-	-	-
Org. Namarroi	no	1	Dearte Nunes	Gurué	471	400	?	Luca
		2	Alverca	Gurué	471	-	-	-

2.2 THERMAL POWER

Beside the electricity consumption, the tea factories consume large amount of firewood as Eucalyptus to run their steam boilers supplying the hot air dryers. The previous tea oxidising process is stopped and the total moisture content is reduced to less than 3%. During the peak season, the boilers are running almost 24 hours a day.

Most of the tea factories have their own firewood plantation, but with the increasingly tea production, they depend more and more on external sales from private tree growers. Market prices are high due to concurrence of charcoal.

In Mozambique, the population density is rather low compared to neighbour countries (24 inhabitants per km²) and the forest area remains acceptable. The high consumption level for tea processing has not yet significant impact on production cost. Assuming that one m^3 of eucalyptus wood is valued at 98,500 MZM (3.5 USD), the thermal power share reaches less than 20% of the total energy bill.

Nevertheless, tea companies aims to increase their forest cover to be self-sufficient. The conversion from wood to electricity is also wished for tea drying process but this will not be economical from independent small hydro power schemes.

3. LOCAL RESOURCES FOR HYDRO POWER DEVELOPMENT

It is interesting to note that many of factories were using hydroelectricity before the national grid reached the region. A couple of those turbines have been reconditioned and are still producing power for the tea factories, but usually below the actual requirements. All factories are using diesel back-up power systems, with negative consequences for the environment and on the cost competitiveness of their products.

3.1 GEOGRAPHICAL AND PHYSICAL INFORMATION OF THE STUDIED ZONES

Mozambique is located between latitudes 10 and 27 degrees South and longitudes 30 degrees and 41 degrees East. Mozambique is bordered by Tanzania, Malawi and Zambia in the North, Zimbabwe and Swaziland in the west and South Africa in the West and South. It has a coastal line of about 2,800 Km, which separates it from the Indian Ocean in the East. The land rises from the coastal plain with less than 200 meters to over 2,430 meters in western and northwestern plateaux. The other topographic features are Lake Niassa (NW) and rivers, which include the Rovuma, Zambezi, Pungoe, Buzi, Lurio, Messalo, Lurio, Save, Limpopo, Incomati, Maputo and Umbeluzi. The total area of the country is of about 800,000 square kilometres. The country is divided into 10 provinces and 128 districts.

The tea growing areas and tea processing factories are located between 15° and 17° latitude South, at heights from 600 to 1200 meters above see level. As shown in the previous map (see § 1.2.3), there are 3 tea growing areas in Zambezia province where tea has been grown and processed so far :

- Around Gurué, south side of the Namuli range, 300 km from Quelimane and 1,800 km from Maputo
- Around Milange, near the Malawi border, 300 km from Quelimane and 1,800 km from Maputo
- In Tacouane district, between Milange and Lugela (Mount Mabu), 250 km from Quelimane and 1,750 km from Maputo

Other potential areas have been identified in other provinces:

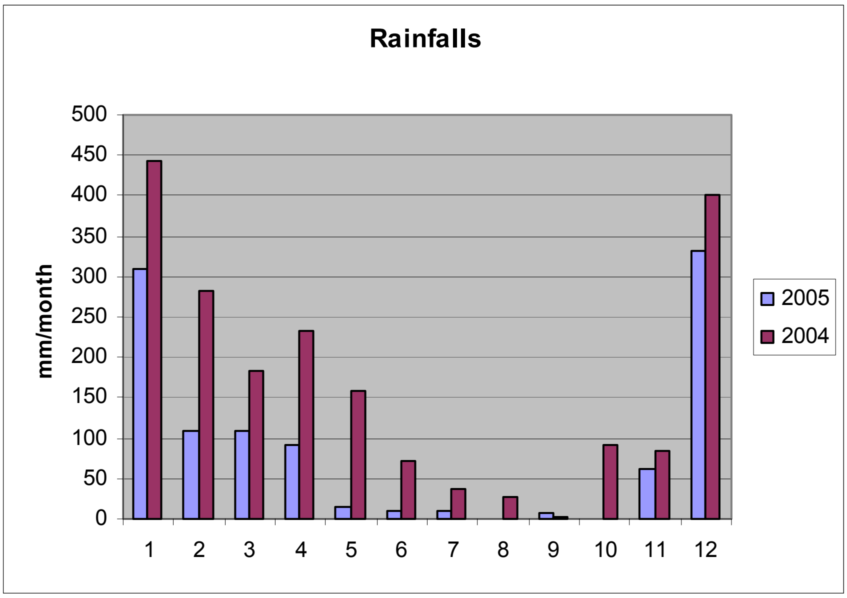
- In Manica province, on the East side of the Chimanimani mountains (>1,200 km from Maputo)
- In Niassa province, in the range of mountains north of Lichinga town.

3.2 CLIMATE-PHYSIOGRAPHY

In Mozambique, the climate is characterised by a rainy season from October to April and a dry season from May to September. The characteristics of each season depend on the dynamics, position and development of the main weather systems such as the subtropical anticyclones over the Indian and Atlantic oceans, the Inter-Tropical Convergence Zone (ITCZ), thermal depressions over the Southern Africa sub-continent and the passage of cold fronts in the south. The rainfall amount depends on location. Experience shows the annual rainfall distribution patterns range from 627 to more than 2,000 mm. The average maximum air temperature ranges from 21.5 to 30ºC (Nov-Dec), while the minimum temperature (observed in July) ranges from 16 to 24ºC.

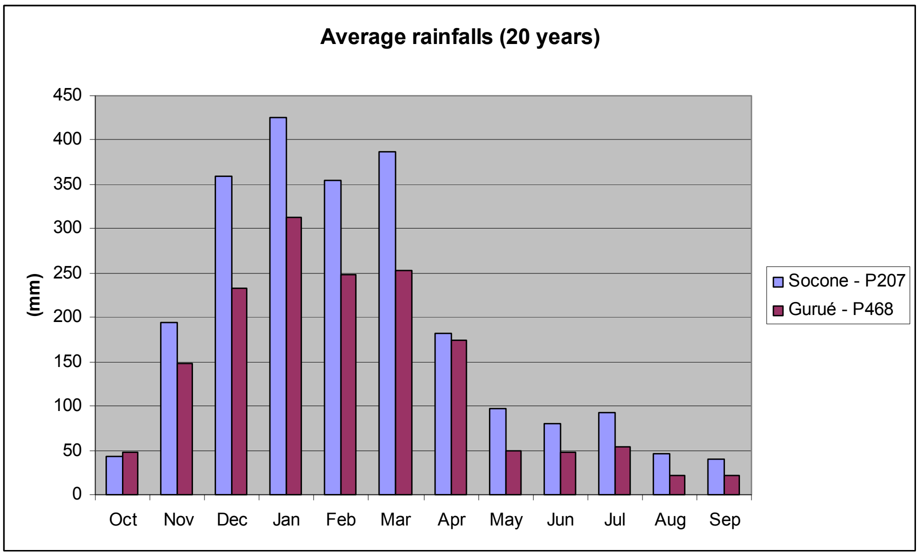
Tea plantation are not using irrigation yet, and depend from the rainfall pattern that may be irregular from one month to another, although the annual rainy values are usually rather regular except for the last year. As illustrated in the figure below, the year 2005 compared to the period 2000-2004 has been a very dry year - with 1,056 mm rain only -, affecting strongly the last made tea production. Tea producers are seriously investigating potential for irrigation to compensate the lack of rain. The minimum value recommended is usually 1,200 mm per annum.

Figure 3 : Rainfalls in Gurué area (2004-2005)



- In Mozambique, year 2000 was famous for severe floods in the southern part of the country but without to much impacts in the northern mountains.
- All efforts to grow tea are currently put in the Gurué and Socone districts, recognised as the best area for tea growing in Mozambique. For example, Gurué receives usually between 1,600 to 2,000 mm of rain per year with a good distribution, i.e. 2/3 of the rain occurs between Dec. and April. Socone and Tacouane seems to be even better. Despite elevation of the plantation, the maximum temperatures occasionally rise up to 36°C before the rainy season (August-November).

Figure 4 : Average rainfalls in Gurué and Socone area (over 20 years)



- During dry season, the crop harvested drops drastically with temperature as low as 7°C.

This aspect is so important that most of the tea factories have they own rainfall meter and keep the measured data on long periods of time. Figures before show the strong decrease of rainfalls in Gurué district during 6 to 7 months from June to October-November, which is similar in most of the tea factories.

3.3 GEOLOGY CONTEXT & SOILS

The following description of the soils in the tea growing regions is generalized due the fact that the Institute of Agricultural Research of Mozambique (IIAM), have not available up to date detailed studies on the matter. Most of the data in this description are from the National Map of Soils on the scale 1:1 000 000, compiled in 1994, by the National Institute of Agricultural Research/Department of Water and Soil (INIA\DTA). According to the adopted legend it is concluded that both districts imbedded in the hinterland of the Province of Zambézia, they don't present large units of pure groupings of soils, except the lithic soils (I), which constitute scattered patches or islands and, in places, a little more extensive areas.

This type of soils is slightly sandy, brown, little deep or little thickness (0 to 30 cm) on the altered parent rock. In eroded sectors, form inselbergs, leaving discovered the rocky outcrops. Usually present mountainous topography with slopes of more than 30%. It possesses an excessive drainage rate, with superficially small to moderate organic matter content.

Basically, the soils both of Gurúe and of Ile are characterized by combinations of two or more units and an underground no salty 0-1m S/cm(?). The risk of erosion of these soils is one of the major restrictions for their use for economic activities (e.g. agricultural use).

In the northwest end of Gurúe there exist very characteristic lithic soils (I), unit which also dominates the central part of the district and scatters a little in the other areas but, in more restricted areas. Below to the unit I of the northwest it is found the unit of brown soils of medium texture and slightly loamy-sandy of considerable depth (KM). Here dominate the "interfluvios" of the medium and inferior hillsides. This material of the Precambrian Basement contains acid rocks, granites and gneisses.

In the center-north appears the combination of clayey red soils (VG) and brownish-grey loamy soils (KG). The first are typical of "interfluvios", superior hillsides and plateaus, with 0 to 8% of steepness. The depth of these soils gets to cross the 100 cm and, they possess good drainage. The others are also deep, and they appear in the "interfluvios", medium and inferior hillsides, with the same undulation degree. They are fragile and quite sensitive soils to the erosion.

The northeast is dominated by red soils of medium texture (VM) combined with the lithic ones (I). Precisely in the headquarters of the district of Gurúe the red soils are of medium texture and oxics combined with the loamy-clayey ones brownish-grey (VMo + KG).

The south of Gurúe has the typical combination of loamy-clayey red soils oxics (VGo) with the brown ones of medium texture oxics, "dístricos" (KMo). The Vgo are deep and originated from the Precambrian Basement, built up of acid rocks, granitic-gneisses. They form a topography smoothly wavy of up to 5% of slope and with good drainage. As well as the other ones they are also deep, but with topography almost it glides forming "interfluvios" of plateaux.

The district of Ile has two great combinations of soils:

- in the north VGo + KMo, and dispersed stains of I, and
- in the south KA + VM + C, besides the small strip of KM, above described, that is prolongated in the northeast-south direction.

The unit C is of colluvium soils no specified, of brown-greyish colour and variable texture. It appears in topography almost it glides between 0 and 2%, shows an imperfect and bad drainage. It is typical unit of Dambos, derived from Precambrian rocks of the type granites and gneisses.

3.4 HYDROMETRY & HYDROLOGY

The detailed area that has been studied contains the factories around Gurué and Socone towns. Several attractive hydro sites have been identified down to the Namuli mountains on both South and North sides of the range.

The major relevant rivers running close by in Gurué and Ile districts are the following:

- Rio Licungo (+ rio Luça)
- Rio Malema
- Rio Lua (+ Rio Duduce)
- Rio Cocola
- Rio Loci (Socone)

A detailed overview of the rivers in Mozambique is given in the 1:250,000 national maps of the country from which an extract is given in Appendix E. Nevertheless a detailed maps of rivers and hydrometric/climate stations are available at the National Directorate of Water (Department of Information).

The development of the tea in the area has lead to the development of hydrometric and climate stations. Unfortunately, many of them have been operating only for few years and were stopped either because of civil war or because lack of resources to maintain.

Nevertheless the following table summarises the average flow data obtained for the major relevant rivers for our study.

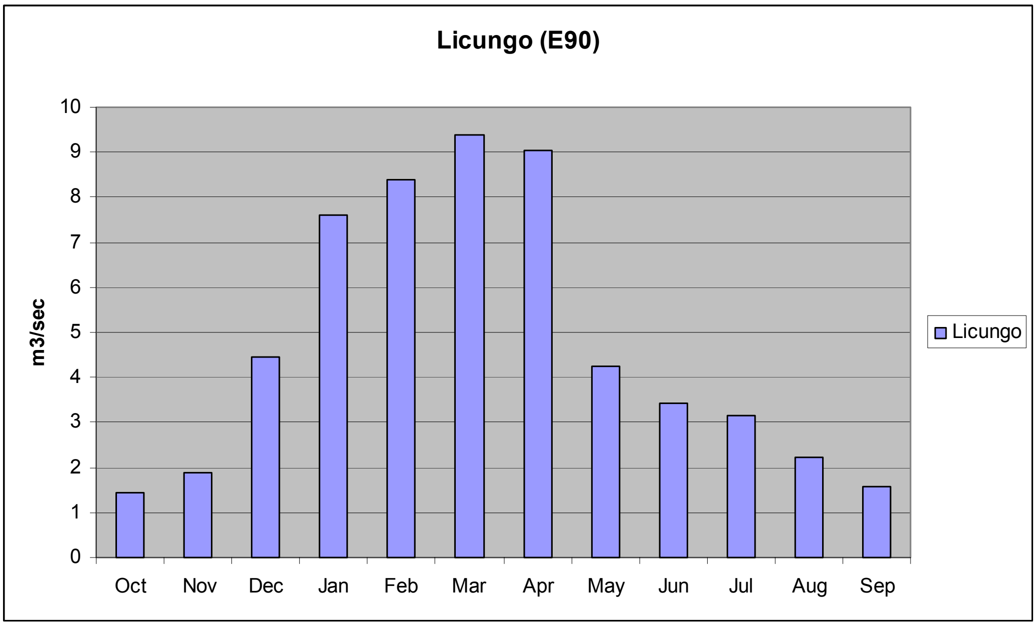
Daily flow data have been collected for the following hydrometric stations :

Gauging Station	Localisation	River	Long			Lat.			Altit.	Water - shed	Av flow (12 months)	Design flow (6 months)	Max flow	Specific design flow (6 months)
N°			*d*	*m*	*s*	*d*	*m*	*s*	*m*	*km²*	*m3/sec*	*m3/sec*	*m3/sec*	*m3/sec/km2*
E 95	Errego	Licungo	37	11	0	16	2	0	390	5800	66,73	86,06		0,015
E 90	Gurue	Licungo	36	56	30	15	28	0		140	4,72	5,75	21	0,041
E 191	Gurue Captacao	Licungo	36	58	30	15	25	0		40	2,094	2,52	19	0,063
E 109	Errego Gurue	Loci/Muliquela	37	8	0	15	56	30	420	803	13,58	15,25	85	0,019
E 454	Nauela	Lua	37	19	0	15	30	0	0	82	1,17	1,31	2,9	0,016
E 389	Confluencia com Licungo	Lua	36	57	0	15	28	0	650	72	1,7	2,05	12	0,028
E 114	Gurue Casal s. Pedro	Luca	36	54	32	15	24	57	0	0	no measures			
E 412	Malitchane	Malema	37	18	0	15	8	0	740	858	missing			
E 190	Montes Namuli	Malema	37	6	30	15	23	0		90	5,43	6,71	35	0,075
E 443	Morrua	Melela	37	52	0	16	16	0	0	2015				
E 491	Minhoto	Menembo	36	55	0	15	21	0	0	0				
E 409	Mugema	Molocue	37	4	0	15	24	0	700	325				
E 400	Mucunha	Namparro	37	13	0	15	15	0	950	188	4,88	6,41	28	0,034
E 460	Est. Lioma Nantulo	Namule	36	57	0	15	8	0	0	0	4,17	5,54	35	?
E 107	Est. Errego Gurue	Narre	37	1	0	15	32	30	620	90				
E 219	Mulevala	Nipiode	37	36	27	16	26	36	205	1065				
E 406	Lioma	Nualo	36	48	0	15	10	0	690	175				

- Most of the hydro sites were already identified before the 1980s and some have been equipped with SHP for the tea factories before the electrical grid came.

- The data collected are not complete and few recent data are available. Most of the gauging station having not been used after 1996 and only some years are available during the period 1970s – 1990s.
- Tea production as mentioned before is strongly affected by the rainfall variation, as well as the river flows. The next curve illustrated the average flow variation during the year for the Licungo river (average value over 30 years).

Figure 5 : Average water flow on Licungo river (m^3/sec)



- For this reason, the design discharge flow has been calculated as 80% of the average monthly flow over the 6 months of production (December – May).

3.5 Site Accessisbility – Road Infrastructure

Only one road out from Gurué is a good tarmac one going to Alto Molocué; others are unpaved or gravel roads.

As many of the hydro sites are located inside the plantation area, the location of the hydro sites is often close to secondary roads that are well maintained if the factory is operating (for tea leaves collection).

3.6 National know-how / capability for small hydro development

This chapter shows the situation of national know-how and capability on the technical point of view and what is necessary to do to improve the situation, in the fields of engineering, implementation, supervision, commissioning and maintenance of SHPP's in Mozambique.

3.6.1 Engineering and consultancy for Small Hydro Power Plants

Despite the high potential for hydropower development, local engineering services are not readily available for SHPPs, due to the long civil war period. Till now, most of the services have to be supplied by foreign engineering offices. If this project is implemented, training of local engineers will be necessary. Nevertheless EDM is running 2 micro-hydro power plants (< 1 MW) which are connected to the grid.

The actual tea processing companies have been strongly invested in rehabilitation to improve the skills and their manufacturing tools, to be able to compete on the very competitive tea market. So, tea companies have generally their own capacities of management of projects, and know where to get assistance in this field, if needed.

3.6.2 Manufacturing of components

Turbines, Electric components, (Cables, Electric switchboards components, Transformers) : no local manufacturer in Mozambique

Penstocks, piping : no official local manufacturer in Mozambique but CDM factory is manufacturing their own penstock tubes from metal sheets.

3.6.3 Contractors

Civil works : TAMEGA, CMC, CETA, WADE ADAMS,…

Electrical works : ELECTRO SUL, ABB, SOTEQ, etc., …

Micro hydro power plant : ENIEL

3.6.4 Maintenance

Tea companies have necessarily their own capacities in the field of maintenance and repairs in mechanical and electrical field. They repair, modify and manufacture a good part of their machinery in the workshops of their factories, with engineers and technicians. Since the rehabilitation, local skills has been developed for maintaining old hydro-turbines, penstocks and channels. Turbines from 1960s are still operating and are in a very good shape.

There is actually no private service providers for operating and maintenance of SHPP in Mozambique.

3.7 POTENTIAL SITES

- ***Table of identified SHPP potential sites for tea factories***

All tea estates existing in the Gurué-Socone area are located at less than 10 km radius from at least one of the 5 proposed hydro sites, except the UP-7 which doesn't have any factory and has less than 100 hectares of tea plantation.

Some hydro sites (in particular on the Rio Malema) are large enough to supply several factories, if agreement can be found between competitive tea companies.

The following table gives the key information about the identified hydro sites nearby the tea factories. 2 are not relevant due to small watershed area and low head. No accurate data have been found for the old previous hydro sites. At least 5 turbines were used at that time but all relevant information has disappeared during the civil war.

Tea estate	Site	River	Map	Gross head	Water shed	Channel	Distance to Tea Fact.	Specific design flow (6 months)	Design flow	Approx. Instal. Power
New sites	*N°*	*name*	*N°*	*m*	*km²*	*km*	*km*	*m3/sec/km2*	*m3/sec*	*kW*
UP 1-2	1	Luca	471	280	8,6	2	< 10	0,070	0,60	1000
UP 4-6	2	Licungo	471/472	340	16	5	< 10	0,080	1,28	2570
UP 5-8-9-10-12	3	Malema	472	120	110	3	< 20	0,080	8,80	5676
Socone	4	Loci	509/546	60	50	7	< 2	0,025	1,25	400
Socone	5	Lua	509	20	700	3	< 10	0,035	24,50	2509
UP 5-8-9-10	*6*	*Duduce*	*472*	*20*	*35*	*0,7*	*< 10*	*0,035*	*1,23*	*132*
UP 5-8-9-10	*7*	*Cocola*	*472/509*	*20*	*22*	*3*	*< 15*	*0,035*	*0,77*	*83*
Old sites	*N°*	*name*	*N°*	*m*	*km²*	*km*	*km*	*m3/sec/km2*	*m3/sec*	*kW*
UP 1-2	1	Luca	471							
UP 4-6	2	Licungo	471/472	50	40	3	< 10	0,080	3,20	864
UP 8-9-10	3	Malema?	472							
Socone	4	Loci?	509/546							
UP 12	5	Duduce?	472							

The figures of the above table will have to be confirmed with detailed hydrological studies including flow duration curves and topographic surveys to check the heads. More accurate information is also given in the next table.

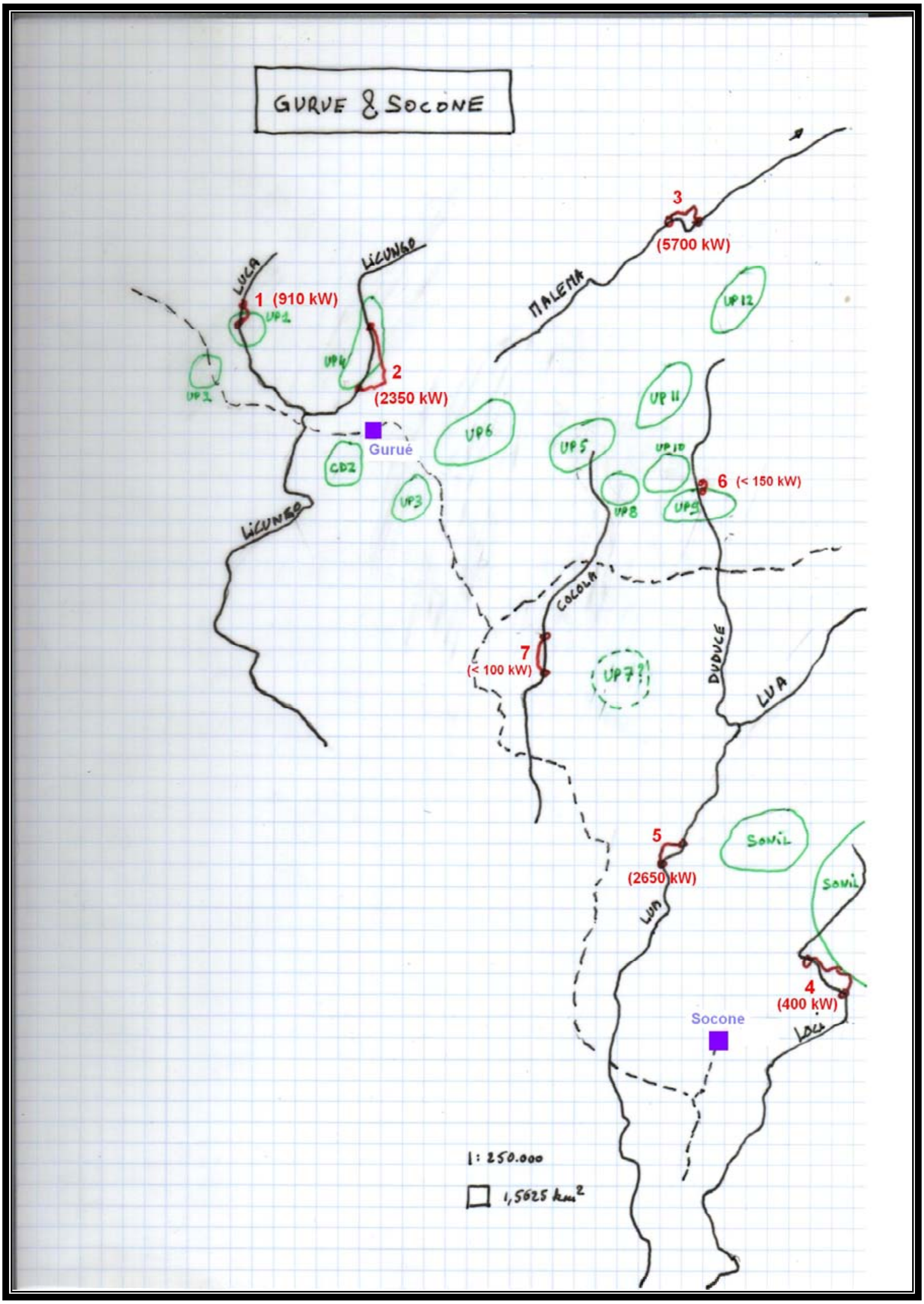
Detailed Hydropower table

			1	2	3	4	5
Map			471	471-472	472	509-510-546	509
River			**Luca**	**Licungo**	**Malema**	**Loci**	**Lua**
Tea Factory			Dearte Nunes	Cha Mozambique		Cha Socone	Cha Socone
			UP 01	UP 04	UP 5-6-8-10-11	-	-
	formula	**unit**					
mean flow							
watershed area	a	km²	8,625	16	110	50	700
annual precipitation	b	mm/a					
water losses	c	mm/a					
annual water volume	d=(b-c)*a*1000	m^3/a	0	0	0	0	0
average flow	e=d/365/24/3600	m^3/s	0,000	0,000	0,000	0,000	0,000
average flow	e=f*a	m^3/s	0,604	1,280	8,800	1,250	24,500
mean flow / km²	f	$m^3/s/km^2$	**0,070**	**0,080**	**0,080**	**0,025**	**0,035**
peak flow							
100 y flood / km²	g	$m^3/s/km^2$	5,00	5,00	5,00	5,00	5,00
100 years flood	h=g*a	m^3/s	43,125	80	550	250	3500
weir							
ground level at intake	H1	m	1060	1040	980	560	580
normal level	H2	m	1062	1042	982	562	582
weir height	H2-H1+e1+0,5	m	4,50	5,50	4,50	4,50	4,50
dam's length	L	m	20	50	25	25	25
water blade thick	e1	m	2	3	2	2	2
spillway flow / m	q=e1*0,5(2*9,81*e1)^0,5	m^3/s	6,264	11,508	6,264	6,264	6,264
spillway length	L1 = h/q	m	6,88	6,95	87,80	39,91	558,73
head							
tail race level	H3	m	780	700	860	500	560
static head	H3-H2	m	282	342	122	62	22
pressure losses	p	m	4,65	7,37	14,51	8,77	4,93
net head	H	m	277	335	107	53	17
equipment							
total equipt flow	Q = Q1*0,8	m^3/s	0,483	1,024	7,040	1,000	19,600
installed power	P =7,5*Q*H	kW	**1 005**	**2 570**	**5 676**	**399**	**2 509**
qy of turbines	nb	u	1	2	1	1	1
flow / unit	Q2	m^3/s	0,48	0,51	7,04	1,00	19,60
power / unit	P2 = 8*Q2*H	kW	1 005	1 285	5 676	399	2 509
productible	W=P*8760*6/12*0,7	**MWh**	**3 080**	**7 879**	**17 402**	**1 224**	**7 692**
penstock							
length		km	0,80	0,60	0,50	0,70	0,50
economic diam	1,5*Q^0,43*H^(-0,24)	m	0,284	0,376	1,130	0,578	2,729
selected diameter		m	0,600	0,900	1,200	1,200	3,000
speed		m/s	1,708	1,610	6,225	0,884	3,500
pressure losses		m	3,21	1,37	10,91	0,37	1,33
canal, road, elec line							
canal		km	1,20	5,00	3,00	7,00	3,00
rough road new		km	0,50	2,00			
rough road rehab		km	1,00	3,00			
33 kV line		km	4,00	9,00	20,00	2,00	10,00
tunnel		km	0,00	0,00	0,00	0,00	0,00

- ***SHPP sites map near tea factories identified in Mozambique***

The following map indicates the potential hydro sites identified, the river names and the tea estates (rehabilitated or disused).

Figure 6 : SHP Site location for Gurué and Socone areas



3.8 CONCLUSION : SMALL HYDROPOWER POTENTIAL IN TEA AREAS

Above table and map show the following facts :

- Very good opportunities of SHPP exist to supply power to existing tea factories in Mozambique as well as for future rehabilitation.
- Deeper investigation is well worthwhile for the 3 rivers Malema, Lua and Licungo because of the high potential hydropower generation and the proximity of several tea factories.
- Extra electricity can be supplied for rural electrification purposes or for other nearby tea factories or agro-industries. The cost of 30 kV electric line will be a very important figure in the investment cost and in the selection of the best sites and local distribution network.

4. GENERAL DESCRIPTION OF THE DEMAND

4.1 TEA FACTORIES

4.1.1 Electric power requirements

The general electrical board to control the various power sources (grid/diesel/hydro) are very old and most of the meters were out of work during the visit. CDM tea factory doesn't have any reactive power compensation and has occasionally to pay for penalties to EDM.

Critical equipments, as new furnaces (with electronic control), are sensitive to voltage fluctuations that may be induced by the small hydropower stations. The grid supply is therefore preferred for such appliances.

In Mozambique, most of the tea factories are using the CTC (Cut – Tear – Curl) process that creates a smaller granular type leaf, ideal for teabags. The process, not much different than orthodox process for black tea in term of power requirements, involves a large number of fans and motors (conveyors, elevators, vibrators, pumps, mixer etc.).

Average total capacity per factory is between 9 and 12 tons of green leaves per day.

The withering process starts daily usually early morning and the rolling or CTC process around midnight. Together they consume about 40% of the daily electricity whereas the drying process requires about 50% of the electricity if 2 boilers are running in the same time.

Majority of the machines are running for long period of time and every day. The peak load usually occurs between 6 and 12 am when almost all motors are running simultaneously : mainly for withering, rolling, drying and sorting stages. For an installed power of 600 kW, the peak power can reach about 500 kW during several hours a day.

Basic equipments are common motors and fans that require high reactive power. Local tea companies, as CDM, has not equipped its factory yet with "battery of capacitors" of few hundreds of kVAR. To avoid EDM penalties, they try to manage the process with series of successive motor starts.

Beside the standard electrical motors of the factory, it is common to find other minor loads as public lighting, water pumping, household supply (with electric cooking plates), usually running during the off-peak hours.

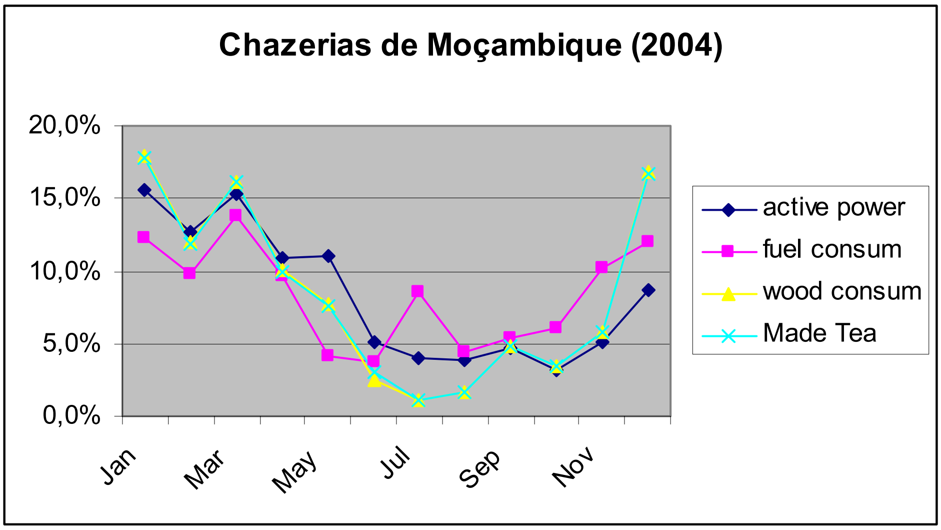
The tea factories keep one day off per week for general maintenance. Beside this "day's rest", the process runs steadily the 6 other days of the week if tea crop is plentiful. Seasonal variation in terms of rain and sunshine strongly affect the green leave production in a ratio ranging from 2 to 5 depending of the tea catchment area and the reference year. During the dry season (May-September), the tea production, and therefore the power requirements, are strongly reduced. The process is then concentrated over a shorter period of time (3 to 4 days instead of 6 days and 12 to 16 hours instead of 24 hours), but daily peak power remains in the same range as in rainy season.

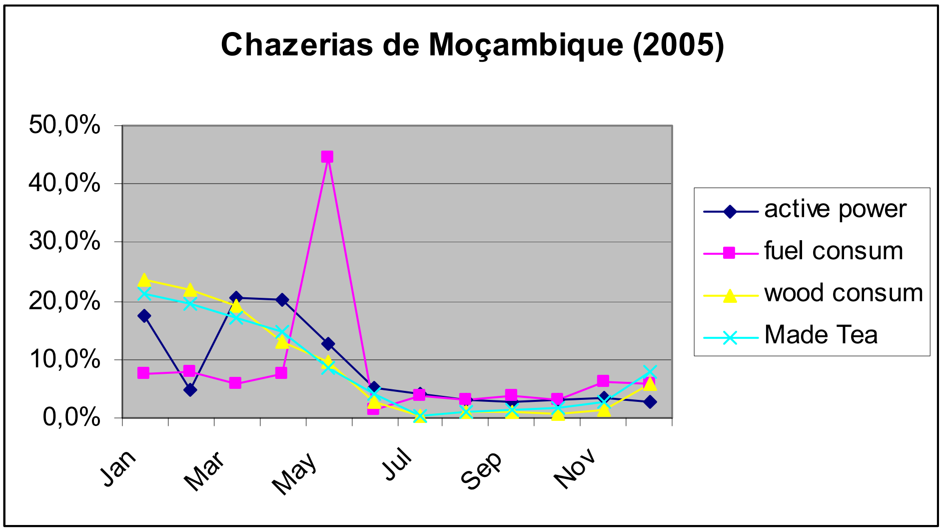
Today, there is still a high potential for increasing tea production in tea factories because rehabilitation of the factory and reconditioning of the tea fields have not yet reached expected yields. Additional investment are needed to improve the production level. Therefore the power load forecast is closely linked to the financial capability of the tea sector to invest in improved techniques and skills (fertilisers, insecticides, grower training, new tea plants, etc.).

The tables given in annex B details the main characteristics of the electrical and thermal power equipment installed in some tea factories, as well as the annual consumptions (electricity, diesel, firewood), the annual bills and the energy costs in the tea production.

The following diagram illustrates the breakdown of monthly energy consumption for CDM tea factory in 2004 and 2005, versus the made tea production. The relative numbers are obtained from the ratio between monthly value and annual value, value being physical quantities, respectively kWh, litre of fuel, m3 of wood, ton.

Figure 7 : Energy consumption and tea production for CDM Lda (2004 & 2005)





Total electricity consumption can be extrapolated from the table for each factory by assuming that diesel generators are producing 3.0 kWh per litre of fuel. In the case of CDM, the diesel generator has produced respectively 2.0 % and 6.7 % of the total electricity consumption in 2004 and 2005.

4.1.2 Thermal power requirements

The requirement of firewood for the tea drying process has already been described in the previous chapter 2. As shown in the previous diagrams, the consumption is closely linked to the made tea production which can vary from 1 to 2, or even more, between dry and rainy seasons.

Typical figures from tea factories in Mozambique indicate that average firewood consumption fluctuates between 3 and 4 m^3 per ton of dry tea. To be self-sufficient and not contribute to deforestation, the factory should harvest at least 0.25 ha of forest for each hectare of tea plantation. CDM company owns 520 hectares of forest (eucalyptus) for 1,400 hectares actually used today, which is enough for their consumption, even if other tea area are rehabilitated in the future (about 900 hectares more).

The tea factory managers are not aware about any cost-effective alternatives. There are expectations to substitute the wood by electricity or gas.

4.1.3 Interest of the tea factories in SHP development

In the context of competitive tea business as well as increasing energy shortage, it is rather obvious that all tea factories are eager to move to cheaper and more reliable sources of energy. The hydro potential if available in the proximity could contribute to the basic needs and reduce the dependence to the diesel and/or to the national grid. Only few managers/owners are aware about

The possibilities of the hydropower for their needs is well known as several hydro turbines are still running in few locations, some for more than 40 years! The technical choice of a run-of-river hydropower system will reduce the investment cost and the impacts on the surroundings but the variation of the river flow will not be compensated and an other source of electricity, as a diesel genset, will still be required to meet the factory needs all the year round. With such hybrid solution, the daily management will not be simplified but considerable savings on energy expenditures.

Amongst the tea factory staff, very good technical skills exist to operate and maintain properly the hydropower plant.

4.2 SETTLEMENTS IN CATCHMENT AREAS

Tea catchment area around the tea factories can spread as far as 25 km from the plant and tea growers may live far away from the tea factory. Usually only households from the staff and workers, and sometimes 2 or 3 villages are located in the proximity of the tea factory.

The situation for CDM factory is rather different as about 200 households for workers are gathered in the proximity of the tea factory (<500m) leading to a very attractive rural electrification scheme with the same hydropower station.

Typical needs in such rural villages include grind mills, some workshops, shops, bars and restaurants, and in the best case public infrastructures (schools, health centres, water pump, workshops, maize mills, battery charging station, administrative offices and worship areas).

Tea buying centres spread around the factory are not often used as tea growers bring their crops directly to the factory. No electrical equipments are needed for the tea collection and quality control.

Around Gurué town (33,700 pop.), several satellite villages are already electrified by the EDM grid. Further extension are planned although the household connection rate is very low due to high kWh cost compared to local average incomes. Improved connection rates can be expected if electrical power is produced locally from mini-hydro and surplus is sold by the tea company at a tariff below the EDM social tariff (3.0 US cents/kWh).

Some of the hydro sites identified near the tea factory sites are large enough to sell electricity to other customers around. Detailed feasibility study should show if excess energy (e.g. during off-peak hours like evening time) can be supplied for other purposes.

4.3 HOUSEHOLDS

The tea factory is usually supplying electrical power to a number of nearby staff houses (between 20 to 40 families) that have rather developed facilities and equipments as refrigerator, electric cooker, iron, water-heater, audio-visual, …

Typical houses from tea workers or growers and other farmers doesn't have all this consumer goods. Electricity if available is used only for basic lighting, radio and eventually small television.

4.4 OTHER ECONOMIC OR INDUSTRIAL ACTIVITIES IN THE AREA, AGRO-INDUSTRIAL

There are few agro-industrial activities in the Gurué area (Dhal factory) that could benefit from new electricity power supply, but not in the vicinity of the tea factories

5. REGULATORY FRAMEWORK

5.1 CURRENT RELEVANT ACTIVITIES IN THE POWER SECTOR (DEREGULATION, PRIVATISATIONS)

Since the nineties a programme of energy sector reform has eliminated the state's monopoly rights in the energy sector (with the exception of electricity transmission). The reform programme has also entailed wide-ranging organizational initiatives to help public companies operate on a more commercial basis. In 1997 various pieces of legislation altered the status and competencies of the two main state companies in the energy sector, Petróleos de Moçambique – PETROMOC (oil products) and Electricidade de Moçambique – EDM (electricity). The first became a limited liability company and the second became public company with the obligation of signing multi-year programme contracts with the Government, outlining their performance objectives. A council of Ministers decree established new conditions for the import and distribution of petrol products and a market-based pricing system, while another introduced management contracts for district electricity facilities.

The 1997 Electricity Act (Law 21/97, from 1st October 1997) opened up all aspects of electricity production, distribution and sale to private operators through concession contracts, according to the decree 8/2000, from 20th April 2000, determined the legal and financial autonomy of public companies and stipulated that they should function on a commercial basis and be financially viable. It includes provision for compensation for companies required to apply below-cost prices. But responsibility for the management of the high voltage transmission system is reserved for a public entity. While the role of private actors in the petrol distribution sector has increased substantially, EDM still dominates the electricity. Concerning EDM important issues of the reform include unbundling of the company and separation of accounts. Although the reform programme envisaged considerable private sector participation, particularly at district level, this has not occurred yet. Mozambique's nascent private sector is still small and fragile and other field of endeavour offer more secure promises of return.

5.2 KEY INSTITUTIONS AND ACTORS

The Ministry of Energy (ME) has prime responsibility for the energy sector. It comprises the new National Directorates of Electrical Energy (DNEE), of New and Renewable Energies (DNENR) and of Fuels (DNC) dealing with policy and regulation. The small hydropower development is under the DNENR responsibility but is linked to the NDEE where medium and large hydro power are dealt. DNENR is promoting micro-hydro for rural electrification with isolated grid and looks for financing identification studies for potential sites in prior districts (Zambezia and Niassa) and new or update feasibility studies.

The all important forest resources are under the responsibility of the Ministry of Agriculture (MA). The Ministry for Coordination of Environmental Affairs (MICOA) has an important potential role in documenting and monitoring the effects of both the extraction and end-use of energy resources. MICOA is promoting clean energy sources and propose assistance for project design with CDM mechanisms. Moreover, some of the most important international programmes and projects with strong energy and environmental component have been promoted under an environmental heading of UNEP and GEF.

Two potentially significant new institutions have been created under the reform programme and are subordinated to the Ministry of Energy. The National Electricity Council (CNELEC), established by the 1997 Electricity Law has as main responsibilities mediation and arbitration in differences arising from aspects of energy supply and pronouncing on policies, projects, concession requests and new technologies. It also supervises tenders. Its broad-based membership includes government representatives, producers, consumer associations, research institutions and the manager of the national grid and concessionaires. The functions of CNELEC are regulated by the decree 25/2000, from 3rd October 2000. The Energy Reform and Access Project – ERAP is pushing to transform CNELEC into a regulatory body.

The National Energy Fund (FUNAE) was also created in 1997 by the decree 24/97, from 22nd July 1997. FUNAE is public institution with legal personality, administrative and financial autonomy aiming at supplying financial aid and financial guarantees for economically and financially viable projects in the energy sector. The focus of activities of FUNAE is to promote rural electrification and the use of renewable energy technologies. Any entity can have access to FUNAE funds. Finance can cover installation, equipment, biomass production including reforestation and forest management, the distribution of petroleum products, studies on energy resources and technologies and the dissemination of information on energy technologies. It can also install and manage systems. During the period 2003 to 2004, FUNAE funded activities of energy surveys in the provinces of Sofala, Zambézia and Nampula in order to help the private sector and non governmental organizations with information useful for their interventions in the energy sector in the mentioned provinces.

Another institution subordinated to the Ministry of Energy is the Technical Unit for Implementation of Hydroelectric Projects (UTIP), initially designed for medium and large hydro projects in the Zambezi valley only. Although not created in the framework of the reforms, its tasks are being adjusted accordingly and its mandate should be extend - in a couple of months - to cover all the country, and to include small hydropower (SHP). They are willing to set a specific master plan for hydropower development in Mozambique (international tendering).

National rural electrification programme concerns 3 ministries : M. of Energy; M. of Planning and development; M. of Works (including Directorate of Water), but the actual planning and regulation is under the NDEE. FUNAI will deal with financing and implementation.

5.3 POLICIES AND PRACTICES OF PPAS BETWEEN UTILITIES AND IPPS IN THE POWER SECTOR

Following the approval of the Electricity Law, MOTRACO (Mozambique Transmission Company) was established and received a concession from the Government to provide power to the Smelting Company MOZAL, based in Maputo, in 2001. MOTRACO gets energy from the South African Power Utility ESKOM. Now it provides around 900 MW to MOZAL. It is foreseen that MOTRACO will get a concession to provide power to the Limpopo Sands Project, to be established in Chibuto, Province of Gaza. Another company, ENMO (Energia de Moçambique) received a concession from the Government for production, transmission, distribution and commercialization of energy in the northern part of the Province of Inhambane. Right now the company has installed thermal stations using natural gas from Pande in the towns of Vilanculos, Inhassoro and Nova Mambone. A larger thermal plant based on gas is to be constructed by the company in Temane to provide power to the whole northern Inhambane. Other smaller initiatives are taking part following the approval of the Electricity Law.

In terms of policies and plans there are two important documents, namely the national energy policy and the national energy sector strategy. The national energy policy was published by the decree 5/98, from 3rd March 1998, and focus on the role of energy in economic growth. The objectives of the policy include:

- Reliable supplies at the lowest possible cost;
- Increased energy availability for households, especially coal, kerosene, gas, electricity;
- Reforestation to increase the fuel wood and charcoal supplies;
- Institutional capacity building;
- Investment programmes (hydropower, forestry, coal and natural gas);
- Increased exports of energy products;
- Increased efficiency in the use of energy;
- Development of conversion technologies and environmentally benign energy uses (solar, wind and biomass)
- A more efficient, dynamic and competitive business sector.

The national energy sector strategy established by the decree 24/2000, from 3rd October 2000, tries to transform the intentions outlined in the energy policy into actions. It is a comprehensive document covering the whole energy sector.

Although there is no official document dealing with rural electrification as such, a study undertaken by the Norwegian company Norplan in the year 2000 with the title “Rural Electrification Strategy Plan” guides the activities of the energy sector. The study was produced to assist the energy sector to establish an official rural electrification strategy plan.

5.4 LICENCES AND AUTHORISATIONS FOR INDEPENDENT HYDROPOWER DEVELOPMENT AND DISTRIBUTION

The water resource management involve several ministries (agriculture, environment, energy, transport, …) and is regulated by the Water Policy (1991) through the grant of concession for the usage of water (Regional Water Authority). A special ordinance is dealing with the license to access water, the permit to build SHPP and the license to operate equipments.

The Electricity Act foresees the granting of concessions for energy production, distribution and selling. The private sector can have its own generating system, can provide electricity to communities around and also sell its energy surplus to the power utility, including buy energy from the utility when it is required.

Beside this policy and its general terms, there is no specific regulation for SHP in Mozambique yet. Although the regulatory framework is ready, there is no IPP yet for SHP. One IPP (ENMO) is producing power (from natural gas) and supply a cluster of villages.

Regulations	Requirements	Responsible authority
Licensing (generation)	For different capacity ranges	Ministry of Energy (ME)
	Required for captive use or only for sales to utility	Ministry of Energy (ME)
	Fees	Ministry of Energy (ME)
	Valid time period	Ministry of Energy (ME)
Licensing (distribution)	Allowed to distribute directly or must sell to utility	Ministry of Energy (ME)
	Fees	Ministry of Energy (ME)
	Subsidies available	Ministry of Energy (ME)
	Valid time period	Ministry of Energy (ME)
PPA	Standard offer or negotiation by project	Ministry of Energy (ME)
Taxes and Levies	Customs on imported equipment	Ministry of Energy (ME)
	Taxes on construction contracts, income taxes	Ministry of Finances (MF)
	Royalty fees for use of site	Ministry of Finances (MF)
Environmental Regulations	EIA (water rights, public hearing)	Ministry for Coordination of Environmental Affairs (MICOA)
	Ecological flow to be left in river after water diversion	Ministry for Coordination of Environmental Affairs (MICOA)

5.5 CUSTOMS, TAXES, LEVIES AND ROYALTIES FOR HYDROPOWER DEVELOPMENT

Power equipments are taxed at entry for private sector but possibilities to be exempted for critical sectors! The overall tax is of 26% (including 17% VAT and duties).

Petroleum products are heavily taxed by the government.

6. STRATEGY FOR SHP DEVELOPMENT

6.1 SWOT ANALYSIS, BARRIERS IDENTIFICATION

Strengths	Weaknesses
• Country with a dynamic economy • Tea factories have shown strong interest to investigate alternative source of energy and also for social dimension. • Tea sector has long private history. • Climate is favourable to tea growing all the year round • 5 rivers with good potential for hydropower have been identified, these could benefit not only the 3 tea factories who have expressed their interest but also others. • several tea factories have had micro-hydro plant in the past (before the war). Some are still running. • National know-how on hydro power development exists (old) but need to be reinforced • Government support for hydro development, for Rural Electrification and for IPPs support. • Existing legal and regulatory frameworks as well as enacted Electricity Acts • Utility eager to discuss with IPPs • Utility tariff is reasonable for Tea Factories, rated at > 0.10 USD/kWh. • Grid power quality is acceptable.	• Lack of investment in power generation and distribution the last 15 years • No government support for tea promotion • Lack of technical and financial skills in energy sector; limited implementation capacities • Rainfalls and water level seem to be affected by the climate changes • Commercial loans set at high interest rates, up to 30%. • Some tea location have concentrated rural settlements around but capacity to pay electricity remains questionable. • Tea companies require assistance in making right decisions. • Potential for CO2 savings are limited to replacing diesel fuel – 50,000 to 100,000 litres per year. • Power in Mozambique has been strongly hydro-based, meaning low CO2 savings, but current trend is to use more and more diesel genset. • No national EATTA organism exists in Mozambique
Opportunities	**Threats**
• Large national potential for hydro development • A dynamic hydro power sector. • An enthusiastic tea private sector, eager to develop business.	• Tea Industry facing hard times due to low market costs coupled with increasing production costs, and low rainfall season.

6.2 BUSINESS MODEL RECOMMENDATIONS

The most simple and the most efficient business model will be the Tea factory itself investing in and operating the project. This implies that generated power will not exceed the demand of the factory alone.

A second option is to attract external investors who would create an IPP and sell power to the tea factories and take care of the rural electrification component. The latter has its risks in terms of ensuring that an attractive tariff is set. Very few IPPs of similar generation size are operating in Mozambique; their experience would be fruitful.

A third option is a combination of the above, wherein the Tea Factory operates and invests in the SHP, uses electricity for its own consumption and the remaining power, if any, is sold at wholesale quantities to a range of clients or to EDM. A PPA will have to be agreed with the various customers; being other tea factories and an operator in charge of distributing electricity to rural areas or EDM.

A last option is that the electricity generated could be sold directly to EDM MV line through a PPA, or their network could be utilized through a power wheeling agreement (PWA) from the SHP to the tea factories.

With regards to the rural electrification component most of the Tea Factories are eager to supply power to their workers around as well as public infrastructure but they are reluctant in getting involved in selling power which is not their core business and which might be highly risky.

The community itself may be interested in acting as an operator for administering the distribution of power to rural communities. It should be noted that in particular communities that benefit from a fair trade system have access to significant finance and funds which could help in the rural electrification component.

6.3 MAKING FINANCING AVAILABLE FOR HYDRO POWER INVESTMENT

There are several financial institutions having recently re-engaged in hydro development in Mozambique, in particular through the following ongoing projects:

- Recently, at least 6 sites have been identified and proposed for micro-hydro projects but no financing were been beyond feasibility studies. Unido is just supporting one pilot project out of 4 feasibility studies conducted by Indian and Chinese consultants.
- Several other donors as Danida, SIDA, Norad are supporting small & micro hydro sector through financing information update, feasibility studies, policy formulation, but they are not committed to contribute in the investment yet.
- FUNAE offers soft loans to support renewable energy projects and will contribute to the promotion of microhydro development with subsidy of 0.6 USD/kW for SHPP smaller than 3 MW. FUNAE will channel funds in the proper way.

Other financial institutions contributing to the power sector are : World Bank, ONUDI, GTZ, African Development Bank (AfDB), Nordic Development Fund (NDF), Swedish International Development Agency (Sida), Islamic bank, OPEC, etc.

The micro credit sector is not much developed but FUNAE may collaborate with local banks. Main commercial loans are obtained from the Banks of (Banco Internacional de Moçambique- BIM), (Banco Austral),(Standard Bank), (BCI FOMENTO)..

6.4 IMPROVING TECHNICAL CAPACITY IN-COUNTRY FOR SMALL HYDRO DEVELOPMENT

The national capacity on micro hydro power development is rather limited in Mozambique today. Very few engineering consultancy firms are present, and no companies are manufacturing components used in hydro schemes. But the potential for SHP implementation is so important that private investors and service providers should emerge soon.

The few projects involved in SHP in Mozambique (mentioned above) will have a capacity building component to reinforce the technical and managerial skills. Combined efforts could be mutually beneficial.

6.5 SUBSIDIES AND SUPPORT AVAILABLE FOR PRIVATE SECTOR RURAL ELECTRIFICATION

The Government of Mozambique clearly supports the development of micro hydro-based independent grids and gives high priority on rural electrification. As mentioned above, a rural energy fund (FUNAE) has been created to ensure a smooth implementation programme for rural electrification with renewable energy sources.

Stronger support to private sector and special incentives will be needed to attract new actors in the SHP business. The profitability may be affected by the limited rural market and the low average rural income to pay for electricity service.

7. CONCLUSIONS

Mozambique has substantial fossil fuels resources (natural gas and coal) for large power generation. However, exploitation of these resources for national use is limited. In fact, most of Mozambique's primary energy consumption is met by traditional biomass fuels such as wood, charcoal, and agro/animal waste.

The tea producing areas, concentrated in the province of Zambézia, have a plenty of hydro resources which could be used for the development of local agro-industry, as well as nearby rural electrification and social development. In fact most tea factories are equipped with micro hydro schemes since their establishment before the seventies and such schemes have been the driving force of the tea industry. Right now the rehabilitated tea factories after the civil war are working in the districts of Gurue and Ile, province of Zambézia. Major difficulties are associated with the fact that most hydro plants have been destroyed during the war. There is an urgent need to rehabilitate such infrastructures and also identify new potential in order to foster the tea industry. Even in places where there is electricity from the grid, micro hydro plants can be attractive if they can produce electricity at lower prices that that provided by the utility.

The three EATTA member tea companies (CDM, SDZ and Sonil) are located at proximity of important rivers (Malema, Lua, Licungo) from which large amount of hydropower can be produced to cover all the factory needs as well as the nearby villages needs.

Analysis of the institutional and regulation framework of the country reveals that the reforms in the energy sector create the necessary enabling environment for private investments in the sector. Particularly the Electricity Act foresees the granting of concessions for energy production, distribution and selling. The private sector can have its own generating system, can provide electricity to communities around and also sell its energy surplus to the power utility, including buy energy from the utility when it is required. Furthermore the establishment, by the Government, of the National Energy Fund (FUNAE), with tasks more oriented for rural electrification by use of renewable energy technologies can be a good support for the EATTA project, as some of the resources needed for the rehabilitation and/or construction of new hydro schemes can be mobilized locally.

Therefore a pilot hydropower project in this tea producing area with modern equipment and appropriate sizing will be of great benefit for the local communities and their economic development.

Appendix A: List of Contacts

Organisation	Contact	Title	Telephone N°	Email	Comments
EDM	Carlos Yum			cyum@edmdipla.co.mz	
Eduardo Mondlane University	Boaventura Chongo Cuamba	Ph.D	+258 823098120	boaventura.cuamba@uem.mz	
FUNAE (Energy Fund)	Daniel Guambe	Electrical Engineer	+258 828171110	danielguambe@hotmail.co.mz	
MICOA	Telma Manjate	B.Sc. (honours) Meteorology	+258 823286210	telmanjate@yahoo.com.br	
DNEE	Antonio Chicachama		+258 823961538	algc@me.gov.mz	
DNENR	António Osvaldo Saide	B.Sc. (honours) Physics		aos@me.gov.mz	
UTIP	Sergio Jeremias Elisio	B.Sc. (honours) Mechan. Engineering	+258 823297060	se@utip.org.mz	
CDM Lda	Almeida Lee	Director Manager	+258 825167670	gg.alee@teledata.mz	
CDM Lda	Aquil Rajahussen	Administrator	+258 843000180	pca@aircorridor.co.mz	
SDZ Lda	Nuno de Molo Egidio	Vice-chairman	+258 823095710	nuno.egidio@sci.co.mz	
SDZ Lda	Matheh Matheh	Tea Factory Manager	+258 824488810		
SDZ Lda	John Victor	Managing Director		sdzmoz@teledata.mz	
Sonil Lda	Mohamed	Managing Director		asjholdings-moz@itservices.co.mz	

Appendix B: Tea Factory & Plantation Characteristics

Table 1 : Major characteristics of tea factories

MOZAMBIQUE						Plantation		Production Made Tea		
Factory name	Tea Company	District	Distance from Maputo	Year of establishment	Process type	Tea plantat. (Ha)	Tree plantat. (Ha)	Capacity (T/year)	Production in 2005 (kg)	target 2007
CDM	CDM Lda	Gurué	1800	1998	CTC	1400	520	1500	862347	1500000
SDZ	SDZ Lda	Gurué	1800	1999	CTC+…				*1700000*	
Cha Socone	Sonil Lda	Ile	1800							
1 USD =	**28000**	MZM								

Table 2 : Power equipments and facilities

MOZAMBIQUE	Load		EGZ			Genset nom. power (kW)				Boiler/Furnace	
Factory name	Installed capacity (kW)	Peak load (kW)	Rated transfor. (kVA)		Capac. (kVAR)	n°1	n°2	n°3	n°4	n°1	n°2
CDM	550		498		0	414				18cm	4*12
SDZ			1130								
Cha Socone											

Table 3 : Energy consumption and costs

MOZAMBIQUE	EGZ consumpt. (2005)		Diesel consumption (2005)			Firewood (2005)		EGZ	Fuel	Wood
Factory name	Active energy (kWh/yr)	Annual bill ($x10^3$ MZM)	Gird not availab	Fuel consum. (l/yr)	Annual bill ($x10^3$ MZM)	Firewood consum. (ster)	Annual bill ($x10^3$ MZM)	kWh/ton	liter/ton	Ster/ton
CDM	364046	364,000	5-10%	90000	2,250,000	3100	305,350	*422*	*104*	*3.6*
SDZ	675000	773,000	5%		0	7800	768,300	*397*	*0*	*4.6*
Cha Socone										
1 kWh =	**1145**	MZM	Fuel	**25000**	MZM/l	**98500**	MZM/m3			

Table 4 : Energy consumption and tea production in Chazeiras de Moçambique tea factory CDZ Lda

Site name : **CDZ Lda** **Contact name** M. Aquil - M. Lee **Tel/email**

2004			**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Electricity (hydro+grid)	active power	MWh	1324	1071	1295	925	940	429	339	323	394	269	431	734	8474
	reactive	kVARh													0
	cost	MZM													0
Diesel Generator	running time	hours													0
	fuel consum	liter	7214	5756	8076	5671	2411	2196	4996	2568	3167	3549	6026	7063	58693
	oil consum														0
	cost	MZM	180,350,000	143,900,000	201,900,000	141,775,000	60,275,000	54,900,000	124,900,000	64,200,000	79,175,000	88,725,000	150,650,000	176,575,000	1,467,325,000
Thermal power	wood consum	ster	884.14	592.08	792.74	493.27	379.33	123.02	57.62	83.08	240.17	172.04	285.96	828.34	4931.788
	cost	MZM	87,087,790	58,319,880	78,084,890	48,587,095	37,364,005	12,117,470	5,675,570	8,183,380	23,656,548	16,945,940	28,167,060	81,591,490	485,781,118
Tea production	Grean leaves	kg													0
	Made Tea	kg	221034	148019	200006	123318	94833	37090	14412	20593	60042	43011	71489	207085	1,240,932
Grid + Hydro + diesel		kWhe/kg	6.09	7.35	6.60	7.64	9.99	11.74	24.56	16.06	6.72	6.50	6.28	3.65	6.97
2005			**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
Electricity (hydro+grid)	active power	MWh	681	193	804	780	487	196	156	126	111	118	133	108	3893
	reactive	kVARh													0
	cost	MZM													0
Diesel Generator	running time	hours													0
	fuel consum	liter	6910	7200	5505	6888	41416	1273	3487	2757	3644	2991	5846	5447	93364
	oil consum	liter													0
	cost	MZM	172,750,000	180,000,000	137,625,000	172,200,000	1,035,400,000	31,825,000	87,175,000	68,925,000	91,100,000	74,775,000	146,150,000	136,175,000	2,334,100,000
Thermal power	wood consum	ster	729.96	676.64	592.13	400.85	296.90	87.56	8.50	28.68	27.70	23.35	43.65	182.00	3097.916
	cost	MZM	71,901,060	66,649,040	58,324,805	39,483,725	29,244,650	8,624,660	837,250	2,824,586	2,728,450	2,299,975	4,299,525	17,927,000	305,144,726
Tea production	Grean leaves	kg													0
	Made Tea	kg	182489	169161	148037	127654	74224	35022	2126	8101	12255	13633	23036	66609	862,347
Grid + Hydro + diesel		kWhe/kg	3.85	1.27	5.54	6.27	8.24	5.71	78.30	16.57	9.95	9.31	6.53	1.87	4.84

Fuel cost **25000** MZM/l Wood cost **98500** MZM/m3

	Tea production		**Rainfalls (mm/month)**												
Tea production	**TV (kg)**	**TS (kg)**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
2000			117	190.6	195.4	217.5	103.3	17.9	7.7	36.5	0	245.9	374.4	263.2	1769.4
2001			579.9	363.3	367.6	59.9	24.4	18.8	36.9	39.7	12.5	3.8	65	257.7	1829.5
2002			440.9	488.8	170.3	102.5	50.2	69.36	25.3	24.6	42.2	7	171.9	211.4	1804.5
2003		1,120,072	318.00	382.70	127.44	27.90	36.01	9.36	69.60	46.50	17.00	176.50	83.80	297.60	1592.4
2004		1,240,932	441.9	281	182.3	233.3	158.9	70.6	37.3	27.3	3.7	90.8	83.5	400.5	2011.1
2005		862,347	309.2	108.2	109.8	92.2	14.5	9.9	10.1	0	8.2	0	61.7	332.2	1056.0
														average	1677.1

To send back by email to Taric de Villers - I.E.D. - t.devillers@ied-sa.fr

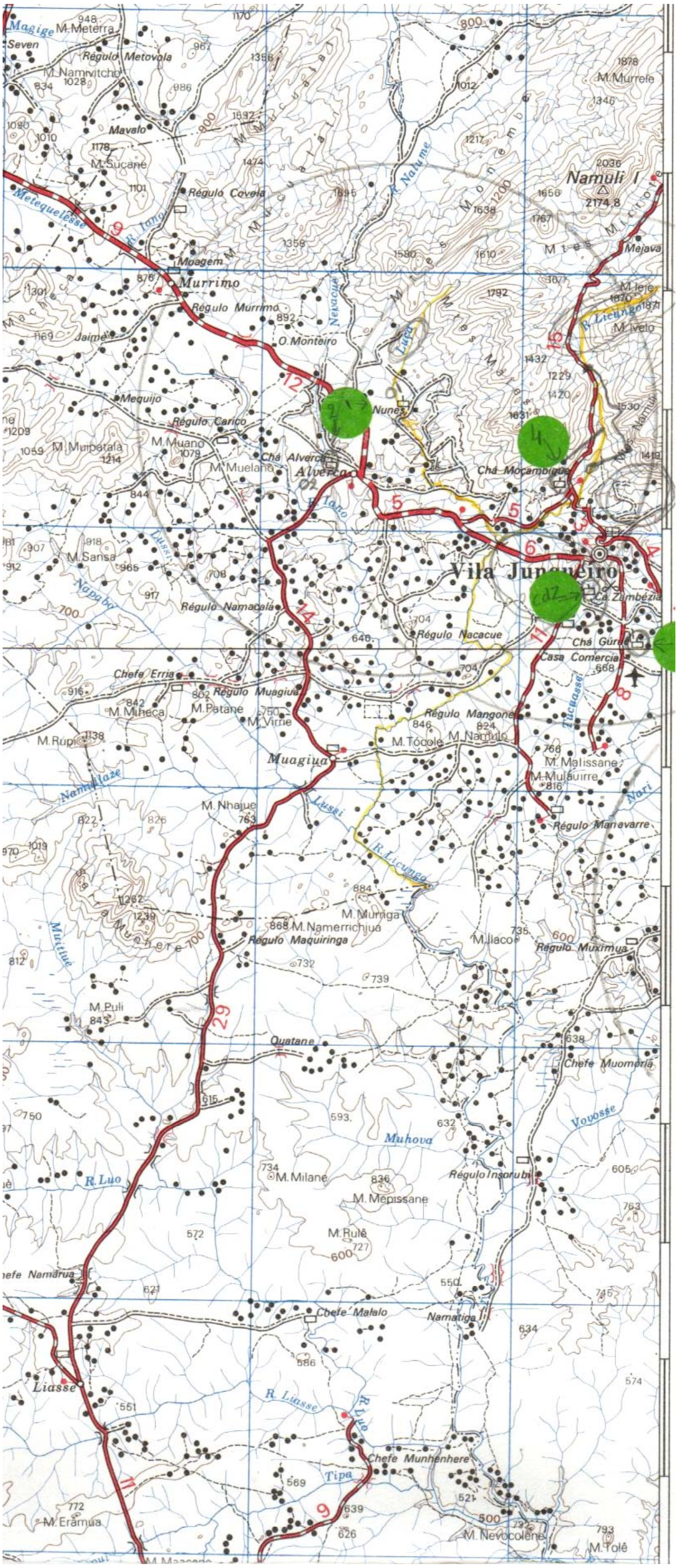
Appendix C: List of potential hydro sites in Mozambique

(Source: Country Situation Report - Water Resources 1998)

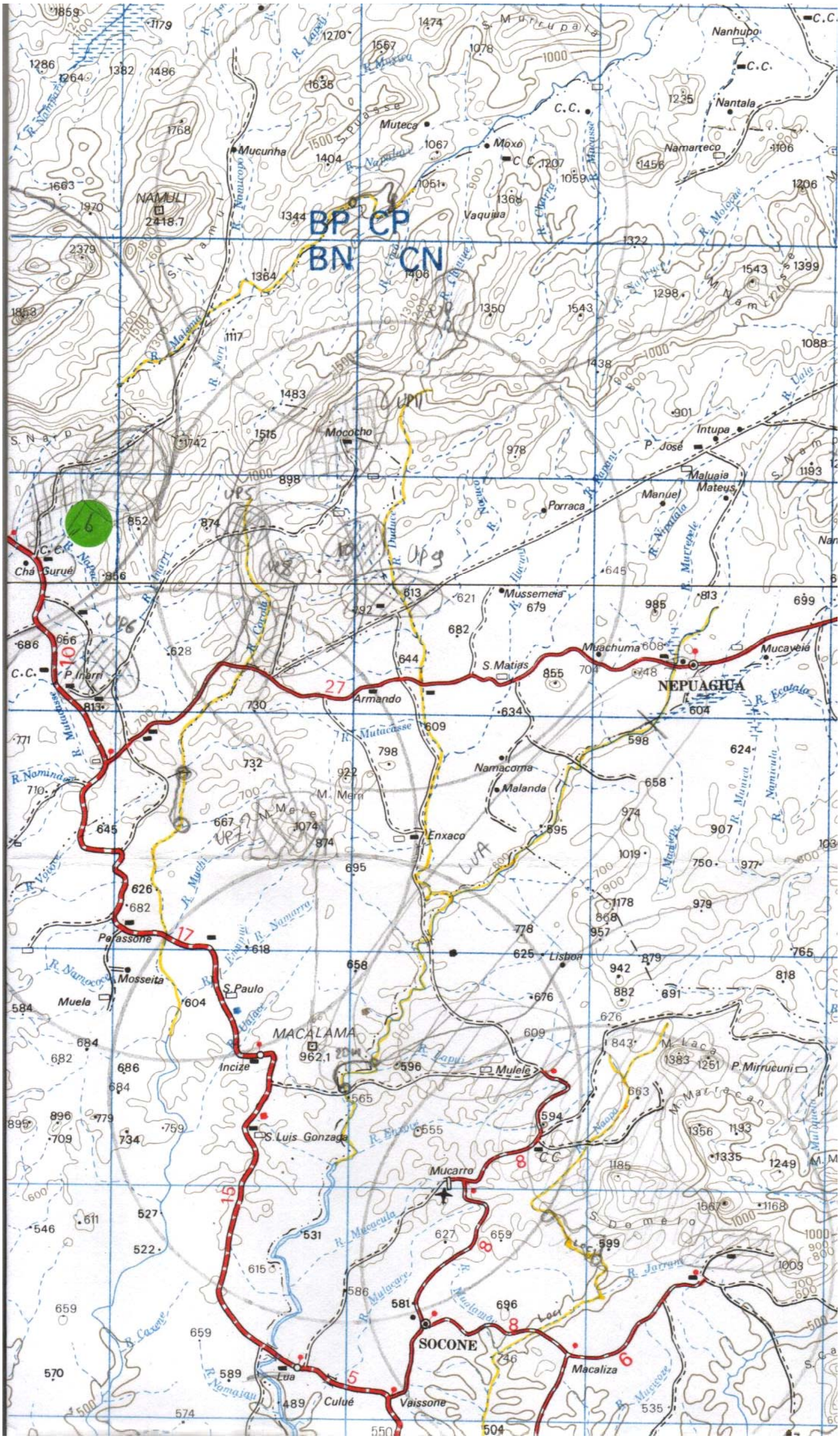
Nr. Identif	Names of Rivers	Potential (MW)	Location (Province)	Nr. Identif	Names of Rivers	Pontential (MW)	Location (Province)
1	Maputo	7,00	Maputo	31	Zambeze (Lupata)	600,00	Manica / Tete
2	Umbelúze	2,00	Maputo	32	Zambeze (Downstream Lupata)	1.100,00	Tete
3	Incomáti	68,00	Maputo	33	Luálua	25,00	Zambézia
4	Sábié	15,00	Maputo	34	Ruo	85,40	Zambézia
5	Elefantes	40,00	Gaza	35	Mulrua	15,50	Zambézia
6	Limpopo	75,00	Gaza	36	Lugela	42,00	Zambézia
7	Save I	20,00	Gaza / Manica	37	Licungo	175,00	Zambézia
8	Save II	25,00	Inhambane / Sofala	38	Luo	22,00	Zambézia
9	Buzi I	300,00	Manica	39	Molócuè I	10,00	Zambézia
10	Buzi II	60,00	Manica	40	Molócuè II	38,50	Zambézia
11	Lucite I	180,00	Manica	41	Ligonha I	40,00	Zamb. / Nampula
12	Lucite II	15,00	Sofala	42	Ligonha II	10,00	Zamb. / Nampula
13	Revuè	250,00	Manica	43	Ligonha III	8,00	Zambézia
14	Púngoè I	70,00	Manica	44	Melúli I	12,00	Nampula
15	Púngoè II	75,00	Manica	45	Melúli II	25,00	Nampula
16	Púngoè III	85,00	Sofala	46	Malema	60,00	Zambézia
17	Púngoè IV	116,00	Sofala	47	Lúrio I	120,00	Nampula / C Delgado
18	Messaze	2,00	Manica	48	Lúrio II	63,00	Nampula / C Delgado
19	Mese	7,50	Tete	49	Messalo	50,00	C. Delgado
20	Mucanha	111,00	Tete	50	Lugenda I	50,00	Niassa
21	Luangua or Duângua	10,00	Tete	51	Lugenda II	50,00	Niassa
22	Zambeze (Cahora-Bassa North)	850,00	Tete	52	Lugenda III	50,00	Niassa
23	Luia	475,00	Tete	53	Lucheringo I	20,00	Niassa
24	Zambeze (Mphanda Nkuwa)	2.600,00	Tete	54	Lucheringo II	20,00	Niassa
25	Lifidzi	2,00	Tete	55	Luángua	5,00	Niassa
26	Maué	15,00	Tete	56	Luaíce I	25,00	Niassa
27	Mavúzi	88,00	Tete	57	Luaíce II	15,00	Niassa
28	Zambeze (Boroma)	400,00	Tete	58	Luché or Mundóa	15,00	Niassa
29	Rovúguè	1.013,00	Tete	59	Timba	15,00	Niassa
30	Luenha	191,20	Manica / Tete	60	Messinge	45,00	Niassa

Appendix D: Maps

Topographic map 1:250,000 (n° 471 & 508)



Topographic map 1:250,000 (n° 472 & 509)



Appendix E : References

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